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THE CONDITIONS OF INFUSORIAL LIFE.

A SCIENTIFIC controversy, carried on by able and assiduous experimenters, cannot fail to enlarge the boundaries of knowledge, although it may not decisively affect opinion on the special subject in dispute. This has been the case with the discussions on spontaneous generation, or "heterogenesis," which have occupied the attention of French scientific men and of the Academy of Sciences for the last few years. The main question has not been elucidated so as to compel the assent of both parties to the same views; perhaps not a single eminent convert has been made on either side, but information has been elicited of a very valuable kind. Before M. Pouchet, of Rouen, came forward as the champion of heterogenesis, the balance of evidence was in favour of those who believe that infusorial life manifests itself only when germs are present, and other appropriate conditions provided; and so the matter still stands. It must not, however, be imagined that the parties to the controversy do no more than reiterate the old convictions. The spontaneous generationists have adopted a substantially new theory, differing as much from the opinions of their predecessors, as the speculations of Darwin differ from those of Lamarck; while the "panspermists," as M. Pouchet calls them, must feel the necessity of modifying their ideas of germs. It is unwise to let the dislike of a doctrine lead to the belief that it is extinct; but this feeling seems to have actuated the authors of that valuable work, the "Microscopic Dictionary," for in the second edition, dated 1860, we find these words in page 312, "the doctrine of spontaneous generation may now be said to have become a matter of history;" although at that very time the *Comptes Rendus* gave ample proof that many of the acutest thinkers in France were engaged in experiments, and counter-experiments, which have not yet ceased.

It is not the intention of the writer to discuss the fundamental principles of the opposing theories; but before giving an account of M. Pouchet's observations, which have a value

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quite independent of his main argument, it will be interesting to show what his views really are, and we find them abundantly stated in his work entitled "Heterogenie," published at Paris in 1859. He declares that he has never said a word to lead any one to suppose that he believes in the generation of animated beings without the aid of vital power; that, on the contrary, he has always thought that organized beings were animated by forces which were in nowise reducible to physical or chemical forces (p. 428). He considers generation, or the manifestation of life on the globe, to have been one of the first acts of creation, and he believes that similar acts are continually taking place. As a rule, heterogenists have developed a system adverse to great convulsions in Nature; but M. Pouchet adopts what may be called spasmodic theories of geology, and he tells us that the manifestations of spontaneous generation do not now reach the same proportions as in ancient times; that they have grown smaller like other telluric phenomena, because we have not now in fermentation that immense mass of dead matter resulting from "so many cataclysms and funerals of animals; and therefore, instead of the gigantic races which surged up from the midst of agitated elements, we only witness the production of the lowest forms" (p. 462).

As will presently be seen, this strange supposition is a most unphilosophical induction from some interesting experiments on the effect of mass, in a fermenting material, in determining the kind of organism which will be produced. M. Pouchet further contends that his views harmonize with the system of Nature, as exhibited in the generation of the higher kinds of animals; and with the opinions of certain physiologists who affirm that in a great number of animals of all classes, the "first lineaments of ovules" have no adhesion to the internal apparatus which produces them, and that the ovules form themselves, under the influence of a special force, in the midst of a granular fluid secreted in the cavity of the apparatus (p. 374). According to this hypothesis, the mother does not form the egg, but it develops itself; and the maternal apparatus exerts a dynamic force upon it, which reproduces the original type (p. 378). In further exemplification of these views, he asserts that the ovary is the seat of an independent genetic force, and that, in like manner, organic matter may be the seat of an analogous force, so that the generation of ovules from what he calls "the proligerous pellicle, or scum which appears on infusions of vegetable matter as fermentation proceeds, is precisely analogous to that of natural ovules in the ovary" (p. 378).

Having explained the chief points of M. Pouchet's theory of heterogenesis, his method of proof next engages attention, and this may be described as a process of elimination. He endea-

vours to show that air, which contains no germs, water, which contains no germs, and a decomposing solid, which contains no germs, may, by mutual contact and influence, give rise to living forms. Here it may be remarked that the almost inconceivable minuteness of some germs, and the great difficulty of insuring their perfect destruction and exclusion, is quite sufficient to throw a doubt upon the accuracy of many of his experiments, without doing any injustice to him as a skilful manipulator; and although we may fail to detect the precise source of error, we are justified, by another class of experiments, in believing that error did exist. It is important, in the present state of physiological science, to deal with these questions inductively; and if certain experiments appear to prove M. Pouchet's theory, they can only be fairly met by counter-experiments of the same kind, conducted with greater precautions, or by analogous experiments of equal importance, and indicating an opposite conclusion. How this has been done will be seen hereafter. Let us now select from M. Pouchet's book the most interesting observations on the conditions of infusorial life.

It is well known that the fermentations or chemical changes in infusions provide one of the necessary circumstances for the development of infusoria, and as boiling infusions checks this action, it is inimical to the appearance of life. Four of M. Pouchet's experiments place this in a striking point of view. Four large vessels were covered by one glass shade, so that all might be exposed to the same influences ; each vessel contained 300 grammes* of liquid. The first was filled with water which had been boiled for fifteen minutes, and twenty-five grammes of hay, which had also submitted to ebullition, and the other three with a different mixture. After three days, during which the four vessels had been exposed to a temperature of 24° centigrade scale (or 75° Fahr.), the first exhibited a slight pellicle and a few vibrions, long and short (*vib. granifer* and *vib. levis*). The second vessel, containing water which had been boiled, and five grammes of hay which had not been boiled, had a well-formed pellicle, a much larger quantity of the same vibrions, and an abundance of kolpods (*K. triticiformis*). The third contained water which had not been boiled, and five grammes of hay that had been subjected to the action of boiling water for a quarter of an hour. This contained the same vibrions as the preceding, more numerous than in the first, and less so than in the second vessel, and also a few of the kolpods. The fourth vase contained water and hay as before, neither having been boiled. Its pellicle was much thicker, its inhabitants the same, but much more numerous. In another case a strong decoction of hay was exposed

* The gramme is 15·434 grains troy.

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to the air for thirty-five days without giving any signs of infusorial life.

Another curious set of experiments was made with fragments of human bone; all the vessels being placed under similar conditions. These vessels were filled with the same filtered water. In the first were five grammes of the skull of an Egyptian, which M. Pouchet brought from the necropolis of Sakkara; the second contained the same quantity of a Merovingian skull, and the third was supplied with pieces from a contemporary cranium. Each was placed under a bell-glass, and left alone for a month, at the expiration of which time the Egyptian bone liquor exhibited a numerous family of epistylis, enchelis, and vibrions. The Merovingian liquor was rich in *Glaucoma scintillans*, to the extent of legions, together with a few vorticellids; neither of which appeared in the first glass. The broth made from a contemporary skull had its own peculiar inhabitants in the shape of kolpods. The three vessels were then placed under one bell-glass, but they still maintained the peculiarities of their population.

M. Pouchet remarks, that it is not only the nature of the fermentable substance, but its quantity, that determines the kind of infusoria that appear. For example, he took similar vessels, placing in each thirty grammes of spring water, but different quantities of hay. They were all covered by bell-glasses, kept at about 75° Fahr., and examined in a week. The first, with ten grammes of hay, had a thick pellicle, and the liquid contained a great quantity of *Kerona lepus*, some pear-shaped animalcules, and large cysts. The pellicle likewise contained a quantity of small cysts. The second vessel, with five grammes of hay, had a thinner pellicle, no keronians, a few piriform creatures, and fewer cysts. The third vessel, with two grammes and five decigrammes of hay (that is, about thirty-three grains), showed no keronians, no large cysts, a few small cysts, and very minute indeterminable animalcules. The fourth glass, which had one gramme twenty-five centigrammes of hay (about nineteen grains), presented infusoria, "infinitely less than those in the first vessels, and of indeterminable character."

Pouchet considered, somewhat hastily, that these experiments proved that the air was not the vehicle of the germs, and that the quantity of the decomposing matter exercised some peculiar influence. To the latter part of this supposition, he calls it a "puerile objection" to affirm that the requisite aliment existed in different quantities. It should however be remembered, that a proximate analysis of hay would show that it contains certain substances in exceedingly small proportions, so that the fermentation of a little bit would only give rise to an infinitesimal quantity of particular products. It has long been known that a large mass of

hay in a pailful of water is more productive of the higher forms of infusoria, than trials made in a tea-cup; but we cannot ascend by such experiments to the spontaneous production of the mammoth from the general smash and corruption of older families in the organic world. Tropical swamps exhibit some of the conditions of vastness of decomposition, which M. Pouchet considers essential to the exhibition of heterogenesis on a grand scale; but can he show that they produce larger creatures than would appear, if similar materials were operated upon under the same atmospheric conditions in an experiment of moderate size?

The state of division of the fermentable matter exercises a considerable influence on the generation of infusoria, by hastening the chemical changes which make the fluid their fit abode. Thus, a vessel containing water and chopped hay produced a richer and different crop of animalcules, from another in which the hay was in a mass. With respect to the influence of different sorts of water, M. Pouchet coincides with Burdach in finding that of dew the most prolific; after which comes rain-water, and then spring-water. He likewise observes, that water which has been boiled is less favourable to the production of infusoria than the same fluid in its ordinary state. Such observations are easily explicable upon the theory of germs; but by adopting a singular process of reasoning, M. Pouchet endeavours to show that they support his own views.

As mincing the fermentable material increased the productiveness of the fluid by accelerating decomposition, we should expect a similar effect would follow an increase in the supply of atmospheric air; and accordingly if two vessels are taken, and in one chopped hay is kept near the surface, and in the other the same substance is retained under a greater depth of fluid, the first will exhibit the earliest, most numerous, and highly developed life.

The prevalent theory of the distribution of germs supposes the air to be the means of their dispersion, by first suspending them, and then dropping them, wherever atmospheric dust falls. It likewise appears, from numerous experiments, that a fresh supply of air is necessary for the production of the higher forms of infusoria, and that liquids in close vessels only yield lower kinds; the probability being, that some of the gaseous products of decomposition exercise an inimical effect, when they are not permitted to escape. But although pure air may, with some exceptions, be designated, with M. Pouchet, "indispensable to the life of microzoaries," he discovered that the vacuum of an air-pump did not destroy them. Fray and Burdach stated that infusoria appeared in an atmosphere of hydrogen or nitrogen; but M. Pouchet sums up the results of numerous experi-

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ments by affirming, that he has never seen the appearance of a proto-organism in water deprived of air, or in water aerated with nitrogen, hydrogen, or carbonic acid; oxygen alone forming an exception. We may here cite a curious observation of M. Pasteur,* on the peculiar fermentation which produces butyric acid. The agent in this process he declares to be an animalcule, which appears in considerable numbers, like small cylindrical rods, isolated, or united in groups, moving in undulations and "pirouettes," and multiplying by fission. They may be transplanted like yeast, setting up the butyric fermentation in appropriate substances; and they have this peculiarity, "not only do these infusoria live without air; but air kills them. Carbonic acid does not affect them."

The influence of heat and light on the production of infusoria engaged much of M. Pouchet's attention; and we find him repeating previous experiments, and adding others entirely new. The results he arrived at were, that no animalcules are generated in infusions kept at a temperature below + 5° cent. (41° Fahr.) In macerations, kept at a temperature of 12° cent. (54° Fahr.), eight days often elapsed before many adult kolpods appeared, while, at 26° cent. (79° Fahr.), four days sufficed to produce "numerous legions, perfectly developed." He likewise observed the tendency of different temperatures to develop different species in the same solutions, and came to the conclusion of Gruithuisen, that from 80° to 96° Fahrenheit was the greatest heat at which infusoria were generated at all. When however they were in existence, they could support extreme changes. Thus, if animalcules living in a liquid at 22° cent. (72° Fahr.), found themselves at the freezing point, in the course of a few minutes, they manifested no inconvenience. In order to test the assertion, that infusoria would revive after being actually frozen, M. Pouchet made several trials, which had the result of showing, that a mass of ice usually contains minute spaces filled with water, which has not congealed, and it is in these that the animalcules live. When however an entire mass was solidified, the larger species perished, and their dead bodies remained, while monads and vibrions frequently escaped. Some vibrions he found able to sustain the intense cold of 15° below zero in the centigrade scale, or 27 degrees below the freezing point of Fahrenheit.

A moderate intensity of light was observed to be more favourable than an excess of luminosity, and direct sunshine in very hot weather had an injurious effect. White light was the most favourable, then red, then violet, blue, and green, for the production of the protozoa; although microscopic vegetation was affected in an opposite way, green being the most favourable,

* *Comptes Rendus*, 25th February, 1861.

blue and violet coming next, and then white light, red being inimical. M. Morren had stated that the action of light was indispensable to the production of vegetable organisms, and that if a series of vessels filled with water were exposed to a more or less intense illumination, those with least light exhibited fewest protophytes and of the most simple construction; but M. Pouchet on repeating his experiments came to an opposite conclusion. In one instance he placed a piece of crumb of bread in a large glass, covered it with three black shades, and placed the whole in a situation of complete darkness. In a week the surface of the bread was covered with blue mould, *Penicillium glaucum*, between the filaments of which were swarming an abundance of *Monas lens*, and several vibrions. In another instance M. Pouchet placed, in a dark corner of his laboratory, an infusion of hay, covered with a bell-glass painted black, over which was put a strong sheet of gray paper, and over this again another black shade with a roll of linen round its base. The whole of this apparatus was further protected against the intrusion of light by double curtains, black, and tawny *(fauve)*. In three days, the temperature being warm, the liquid was covered with a thick pellicle, while monads, vibrions, and kolpods were abundant.

The passage of a current of electricity through the infusion materially hastens, according to M. Pouchet, the production of infusoria, his experiments being performed with one element of Bunsen's battery. Atmospheric electricity afforded still more striking results: the more it abounded, the faster the infusoria appeared, especially if the tension, instead of being suddenly produced by a storm, lasted for several days. Under such circumstances he obtained kolpods as highly developed in three days, as would have been obtained, with the same temperature and less electrical excitation, in double that time.

Contact with mercury, and mercurial vapours, had no injurious effect on infusoria; and, contrary to what had been affirmed by M. Morren, air which had traversed sulphuric acid neither killed them nor hindered their production. A wooden cover, almost touching the infusion, exerted a favourable influence; and the shape of the vessel was important, so far as it promoted, or hindered, the action of light and air on the fermentable matter.

It has been explained that M. Pouchet endeavours to prove his theory of heterogenesis by an exhaustive process of experimental reasoning. He seeks to show that the supposed germs do not exist in the air he employs, nor in the water, nor in the putrescible solid; but still the infusoria appear—produced, as he believes, by the same vital force that presides over the generation of the higher animals; and which, he tells us, "engenders in the ovaries of

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created beings, other beings similar to themselves, while in putrifactive substances it produces only microscopic animalcules." It will at once occur to every reader, that although the germs of the larger infusoria might be excluded with moderate precautions, those of the smaller kinds, which must be extremely minute objects under the highest powers of magnification our microscopes possess, would, if widely disseminated, be so difficult to keep out of any large and complicated piece of apparatus, as to justify doubts in the accuracy of any series of experiments leading to a conclusion demanding unusual severity of proof. And even the successful repetition of any set of experiments, which appear to support a theory at variance with the general conclusions of science, ought not to command our assent unless other modes of testing the question afforded the same results. It would also be reasonable to give greater weight to the simplest methods, if complete in themselves, as offering fewer chances of error, than trials made with more complicated apparatus, and presenting a greater variety of parts. Following this rule, it is no disparagement to M. Pouchet's qualifications as a manipulator if we accept his experiments for their general information, and at the same time reject their conclusiveness for the particular end he had in view. In this spirit we may cite several of his illustrations without recurring to the generation arguments at every step.

Under the head of "Eliminations of the Putrescible Body," we find that maize, peas, haricots, and lentils, were separately burnt in an iron ladle at a red heat, and their remains placed in distinct vessels with distilled water, and covered with separate bell-glasses. In twenty days of warm temperature, the maize vessel exhibited an abundance of a fungus *(Aspergillus)*, but no animalcules, nor did any appear till another fifteen days had expired; the peas yielded numerous and varied microzoaries, and especially *Monas attenuata*. The lentils did the same, and the beans a still thicker population of the same monads. "*Criterium*" vessels, with the same seeds not burnt, produced abundance of animalcules in three days, and of a higher grade than in the former cases. Here we see the influence of minute variations in the chemical composition of the several incinerations, and possibly also of their mechanical condition, in offering appropriate circumstances for the evolution of different germs.

In another experiment, some hay was heated to 200° to 210° centigrade, and even a little higher, till it began to burn, and it was then immersed in distilled water, covered with a plate of glass, and put under a shade. After four days of warmth, the infusions contained a quantity of dead vibrions, with a large population of *Glaucoma scintillans* and minute monads. From these and similar experiments, it is plain that the production

of infusoria is not dependent upon germs contained in solid bodies.

With reference to the water and its action, M. Pouchet elucidates it by experimenting with an artificial combination of oxygen and hydrogen. Having obtained a sufficient quantity of water in this manner, he boiled half of it to destroy any germs that might have fallen into it, and then made an infusion with some hay that had been heated to about 200° centigrade. The whole was covered with a bell-glass, and in a few days displayed two species of paramecia. The other half of the artificial water was treated with hay that had been heated, and yet the same infusoria appeared. These experiments, says M. Pouchet, prove that water is not the receptacle of the "germs" on which his opponents rely. They merely show that water containing no germs will suffice as a medium in which germs from some other source may be developed. Another illustration of the action of water was obtained by skimming off, from an infusion of China aster, "an immense quantity" of kolpods, which were transferred to distilled water, and remained in perfect health for fifteen days; from which M. Pouchet concludes "that it is not the matter dissolved in the water which feeds the microzoaries, or at any rate they can live a long time in pure water." Another curious experiment was performed by grinding up with a muller, or pestle, a legion of kolpods. One half of the homogeneous paste thus obtained was diluted with water, *filtered*, and placed under a bell-glass; the other half was mixed with the same quantity of water, but not filtered. In a week of moderate temperature, the filtered water exhibited an innumerable quantity of vorticellids, and not a single kolpod; while the non-filtered mixture displayed no vorticellids, and no kolpods, but small monads. Upon these facts our author remarks, "The partisans of the transmission of eggs through the intervention of atmospheric air, cannot in any way explain what happened in these two experiments. If the two vessels had contained kolpods, the supporters of ovarism would have declared that the eggs of these animalcules were so small that the grinding process had not broken them up." From a single experiment of this sort no general conclusion can be drawn; but, as we shall presently see, there is no reason to believe that the air contains an unlimited supply of germs of all sorts: one portion will contain none at all; another, those of a particular kind, while a third will differ from the other two. Speaking of the minuteness of certain animalcules, M. Pouchet quotes Owen, to the effect that a single drop of water may contain more monads (*M. crepusculum*) than there are human beings on the globe; and he adds, but this microzoary can manifest itself wherever we offer it appropriate infusions, and that on the aerial diffusion theory,

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the atmosphere must be so encumbered by its germs, that if we add those of other infusoria in similar proportion, we should have the air so crammed with them, that it would almost reach the density of iron. This remark affords an illustration of the good effect of such controversies, for it led to a complete rectification of the thoughtless assertions often made on the abundance of germs; and other experiments placed the question upon a very different footing, as we shall see when we come to the part taken in this scientific warfare by M. Pasteur. In an endeavour to convict the germ party of absurdity, M. Pouchet took a large quantity of beef, divided it into three portions, and placed them in three separate vessels of water, covered with plates of polished glass, leaving an air space of one millimètre* (about a three hundredth of an inch). One of these vessels was put in the roof of the Museum of Natural History, another left in a laboratory on the second floor, and the third placed on the ground floor. In three days each glass was filled with one species of little monad (*M. crepusculum*), to such an extent that if they were to be accounted for by the fall of atmospheric germs, M. Pouchet estimates that more than sixty-two millions must have existed in each cubic millimètre of air. Of course the germ theory does not necessarily demand such an abundance of eggs, and the experiment is a proof of fecundity rather than of anything else.

Observations of what takes place in close vessels are essential to a comprehensive view of the conditions of infusorial life. If air is entirely excluded, we cannot expect to find that any will be developed, unless under special circumstances, like the butyric fermentation, to which allusion has been made. Messrs. Schultze and Schwann published some experiments, in Poggendorff's Annals, in 1837, tending to show that if a maceration was well boiled, and no air admitted except what had either passed through fire or sulphuric acid, no infusorial life would appear. To these M. Pouchet opposed new observations repeatedly performed with great care. M. Schultze placed some vegetable and animal substances in a flask with distilled water, which was boiled to destroy any germs. Two tubes, furnished with bulbs, passed through the cork closing the flask. One tube contained sulphuric acid, and the other a solution of caustic potash, so that all air transmitted through them would come into contact with these destructive substances. The experimenter passed air through the tube every day for two months, during which no form of life appeared, although abundance was developed in a similar flask in the same situation which had free access to the atmospheric. Repeating this experiment with the precaution detailed in his work, M. Pouchet

* The millimètre is ·03937 of an English inch.

found the liquid clear till the twentieth day, when it became cloudy. Four days later he discovered a little blue spot, which was the first appearance of the fungus *Penicillium glaucum*. This plant increased, vibrions appeared, and likewise monads of indeterminable species. The repetition of Schwann's experiments produced a similar result. Messrs. Joly and Musset give an account of similar experiments in the *Comptes Rendus*,* in which they say they have vainly submitted the organic substances employed to prolonged ebullition, in vain submitted the air to a very elevated temperature in tubes brought to a white red heat (*rouge blanc*), or passed it through sulphuric acid; in all cases they found very simple organic substances developed in their infusions. It may be well to mention at this point the observations of M. Pasteur, who has shown that the spores of mildews are not destroyed by being exposed to the action of concentrated sulphuric acid for several days. Other germs of objects of low organization may be equally difficult to kill.

It was considered by M. Pouchet that if the air contained the supply of germs usually imputed to it, and ready for deposition in a suitable liquid, the first washings of the air ought to contain the largest number, and subsequent washings would exhibit a marked diminution. To test this, he took eight of Wolff's bottles, and partially filled them with a decoction of hay, which had been boiled for an hour, filtered, and introduced boiling hot into the vessels. After this he passed steam through the series of bottles for half an hour. They were then left for fifteen days, when every vessel exhibited a population of kolpods, the last of the series being as rich as those preceding it. During two years he frequently repeated these experiments, with various contrivances to facilitate the stoppage of any particles the air contained, and he arrived at the conclusion that "the animalcules were, normally, equally numerous in all the vessels—in the first as in the last." In one case, however, he had the curious fortune to find the first vessel solely occupied with *Navicula obtusa* and a green conferva; the second chiefly with *Dileptus folium;* the third with small animalcules and several rotifers; the fourth with the same conferva as in the first, and some kolpods; the fifth exhibited vorticellæ, epistylis, and glaucomæ, while other objects had been developed in the sixth and seventh. During this experiment a large measure of air was daily blown through the series of bottles. Upon this M. Pouchet remarks, that while the results are inexplicable upon the germ theory, they are easily explained by heterogenesis, as "each vessel has engendered special generations, because it was the seat of particular modifications, which time had diffused unequally through the macerations." The "unequal

* 21st January, 1861.

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diffusion of modifications" appears to be an assumption made to suit the hypothesis—not the observation of a fact; and if true, it might supply the conditions necessary for the development of different germs.

Passing over a variety of experiments that are well worthy of attention, we come to M. Pouchet's remarks on the scum, or pellicle, which makes its appearance on the surface of infusions, and which he calls the "proligerous pellicle" (pellicule proligère). This pellicle, he asserts, is composed of the "*débris*" of "animalcules," at first of the lowest kind, afterwards of higher grades. He gives it the epithet "proligerous" because he considers it to play the part of "an improvised ovary which produces the animalcules;" how those previously formed were produced he does not so clearly explain. Of these pellicles he discovers several kinds:—1. The granulated pellicle, composed of the carcases of monads and bacteriums. 2. The matted pellicle, formed by the interlacement of the bodies of long vibrions. 3. The pseudo-cellular pellicle, which appears after the generations of small monads and vibrions have passed away, and is composed of deceased kolpods, or great monads. 4. The composite pellicle, in which the previous elements are combined. In confirmation of his views, M. Pouchet quotes Dumas to the effect, that if a piece of flesh be left in water, it is resolved into minute organic particles which exhibit spontaneous motion, and which combine to make more complicated forms. A similar observation was made by Mr. H. J. Clarke, of Cambridge, U.S.,* who states that on watching the decomposition of a proboscis of a young *Aurelia flavidula* (a jelly-fish), he observed the whole of the component cells in violent agitation, like a single layer of shot shaken in a flat pan, each cell appearing like a monad, when the inner wall fell to pieces, and they scattered in various directions; others looked like chilomonads, and others like hexamita. The same observer affirms that the fibrillæ of the decomposing muscle of a Sagitta looked and behaved like vibrions, and that Professor Agassiz verified his experiments. In conclusion he remarks, "I do not pretend to say that everything that comes under the name of vibrio and spirillum is a decomposed muscle or other tissue, although I believe such will turn out to be the fact; but this much I will vouch for, and will call on Professor Agassiz to witness, that what would be declared by competent authority to be a living being, and accounted a species of vibrio, is nothing but absolutely dead muscle."

The preceding account of M. Pouchet's labours will suffice to demonstrate that they possess great value, quite independent of the particular theory which he has so ardently espoused. Let us now devote a few moments to some counter-experiments

* *Annual of Scientific Discovery for* 1860. (Boston.)

of M. Pasteur, which are highly instructive. He introduced the same quantity of a fermentable liquid in several glass bulbs, drew their necks out in a lamp, and twisted them in various directions, but left them all open. In the greater number he boiled the liquid for several minutes, leaving three or four in which the heating was not carried to ebullition. All were then placed in a situation where the air was still. In from twenty-four to forty-eight hours, the bulbs which had not been boiled, but whose contents had experienced that temperature in preparation, exhibited "divers mucors," and their liquor was "troubled," while the fluid in the remainder remained limpid for months. Upon these results M. Pasteur remarks, "All the bulbs were open; without doubt it was the sinuosity and inclination of their necks which protected their liquid contents from the fall of atmospheric germs. Common air, it is true, entered briskly at the beginning; but at that time the liquid was very hot, and slow to cool, so it caused all the germs conveyed by the air to perish; and afterwards, when the liquor was cool enough to render possible the development of germs, the air entering slowly allowed its dust to fall in the opening of the neck, or on the walls of the entrance." Upon cutting off the neck of one bulb, and placing the resulting aperture vertically, mildews and bacteriums appeared in a few days.* M. Pouchet attached importance to proving that common air did not abound in germs. M. Pasteur, in the interest of the opposite party, demonstrated the same thing. He took a number of glass bulbs partially filled with an infusion, boiled them to produce a vacuum, and sealed up their necks. These, on being broken in various situations, allowed air to rush in, and were again sealed up. For the most part, the liquor became cloudy after a few days, and the vessels exhibited a greater variety of mucedines and torulaceæ than if they had been freely exposed to the air. But it happened many times in each series of trials that the fluid in some vessels remained as unchanged as if it had received "calcined air," which M. Pasteur asserts to be unproductive, in opposition to M. Pouchet. In the course of these inquiries, air was obtained from various localities, among others, at Montanvert, from the Glacier des Bois, and only one of the vessels filled in that situation gave birth to a mucedine.

Thus we find the two classes of experimenters agreeing in one conclusion, that the air does not contain that prodigious quantity of noticeable germs that former microscopists imagined to exist. Nor have observations been successful in discovering enough germs to account for the appearance of animalcules of the larger sort, which soon occurs under favourable conditions. M. Pouchet has been at great pains to collect the particles which

* *Comptes Rendus*, January to June, 1860, p. 303.

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float in the atmosphere; but while he discovers numerous starch grains wherever men are congregated, and finds that the lungs of animals near towns contain a microscopic débris of all sorts of substances, including even fragments of clothing, neither he nor any one else has met with any number of infusorial eggs. Nor can we even affirm that much progress has been made in recognizing and distinguishing the various germs which different species are believed to produce. It moreover appears that many observers have mistaken certain parasitic animalcules for eggs of the creature they inhabit. At least, so M. Balbiani tells us. According to this gentleman, certain acinetans belonging to the genus *Sphærophyra* enjoy life under two aspects. First, they appear as small cylinders, covered with swimming cilia, and furnished with suckers and styles. In this condition they swim freely, and devour their neighbours in the usual way. Then comes a change in their affairs. They assume a spherical form, strip off their ciliary vestment, but retain their suckers, and wait quietly till touched by some roving animalcule, to which they cling. Gradually they work their way into the interior of their prey, not breaking the tissue, but stretching it before them as they advance, and suffering it to close behind them, leaving only a minute channel by which their numerous progeny subsequently escape. When once comfortably seated in the middle of their involuntary hosts, their peregrinations cease, and their vitality is chiefly manifested by the movements of the contractile vesicle. As they grow, their family increases, and they augment the size of the cavity in which they dwell, without occasioning any apparent inconvenience to the paramecian or oxytrichan which they have invaded. M. Balbiani states, that he has noticed a single animalcule sheltering more than fifty of these parasites at a time.*

THE CUNEATIC CHARACTERS OF BABYLON, ASSYRIA, AND PERSIA—HOW THEY WERE FIRST EXPLAINED.

BY H. NOEL HUMPHREYS.

Long before the brilliant and successful guesses of Dr. Young, and the subsequently triumphant labours of Champollion, had led to the deciphering of the hieroglyphics of Egypt, a young and unknown German scholar, Grotefend, had succeeded in reading several names in the cuneatic character of the Per-

* In converting centigrade degrees into those of Fahrenheit, the nearest whole numbers have been taken.

sian system. It was not till 1818, after the arrival of the "Rosetta stone" in England, on which Egyptian inscriptions were accompanied by a Greek translation, that Dr. Young laid the foundation of the method now adopted for the interpretation of Egyptian hieroglyphics; and it was not till a few years later that Champollion developed his great system of interpretation, which has since been reduced to order and comparative certainty by the labours of Lepsius, Bunsen, Birch, and others.

Unaided, therefore, by the labours which have led to the interpretation of the Egyptian method of writing, and long before any successful attempt had been made to interpret any of the Persian or Assyrian inscriptions of Central Asia, M. Grotefend, in 1808, first read off the names of Darius and Xerxes in the *cuneatic* inscription of Behistun. When M. Grotefend determined to make an attempt to decipher those singular wedge-shaped characters, all was utter darkness on the subject; for the assertion of Tyschen, of Rostock (1798), and afterwards of Munten, of Copenhagen, that the proper mode of reading the cuneatic character was from right to left, was only calculated to mislead; while the supposition of those authors that they were real phonetic signs, though nearer the truth, was scarcely likely to be more advantageous to the student, as, if the characters were read backwards, no useful result was likely to be attained.

The efforts of Grotefend were therefore perfectly unaided by the labours of his predecessors in the field of research, which he entered in the year 1800. The inscription which stimulated his curiosity and led to those first steps which have proved the basis of all subsequent discovery, was the one copied from the rock of Behistun by the traveller Niebuhr; who succeeded, by the aid of a telescope, in making an extremely accurate copy of it, although at a height of 300 feet—about as high (to make an approximate comparison) as the cross of St. Paul's. This inscription, in which the writing, formed into three distinct groups, bore conspicuous evidence of being written not only in three distinct sets of characters, but in three distinct languages. The three groups were, in fact, three copies of the same proclamation, addressed to three different races all owning the sovereignty of the Achœmenian dynasty of Persia. That the inscription belonged to the period of that dynasty, M. Grotefend was led to conclude from a long course of historical study.

In selecting one of the groups of writing as the subject of his experiment, he fortunately pitched upon the one written in the latest kind of character—the Persian—from which system nearly all the pictorial and symbolic signs had disappeared, only the phonetic or sound-expressing characters having been preserved, and these reduced in number to about thirty or forty characters. With these facts, however, M. Grotefend was unacquainted, as

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they are the fruits of recent discovery. He therefore went to work entirely unaided, except by his own indomitable perseverance and ingenuity.

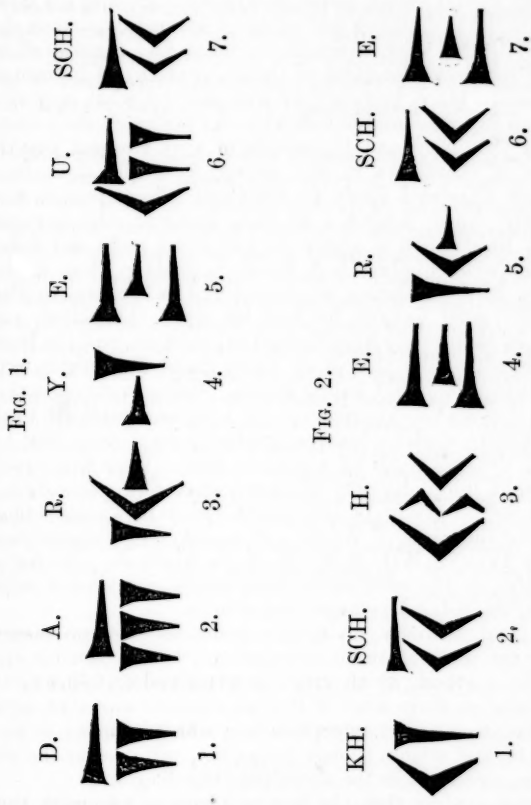
Having determined in his own mind the probable date of the inscription, he next came to the conclusion that, if he could pitch upon a group of characters likely to represent a proper name, he should obtain some clue, or some ground for guessing at the probable meaning and value of several important characters. With this view he endeavoured to find a group of letters likely to represent the name of Cyrus, or of any of his immediate successors. Here, however, he was met by what appeared for a time an insurmountable difficulty, for although such names as those of Cambyses and Cyrus are of very unequal length, the number of characters in any group, which by their frequent repetition appeared likely to represent proper names, were all of nearly equal length. At last, however, the persevering student fixed upon a group to which he gave the following value, experimentally, D. A. R. E. V. SCH. Thus read, they gave the name of Darius, as pronounced in the ancient Persian. By sheer good fortune, he had hit upon the actual name of Darius in this purely hypothetical experiment, and his first step was, therefore, like that of so many great discoveries, scarcely more than a bold and happy guess. Being however led on by certain courses of experiments too long and intricate to detail, the fortunate student became gradually convinced that he had thus hit the bull's-eye by a random shot. With this conviction he sought diligently for another name, and eventually fixed upon a second group of characters which he thought ought to represent the name of Xerxes, or rather, as pronounced in the ancient Persian, KH. SCH. H. E. R. SCH. E. He was again successful, and he afterwards deciphered, in a similar arbitrary fashion, the name Hystaspes and others.

He had, however, up to this point, adopted no method of testing the truth of these assumptions, but at last hit upon an infallible method, which may be explained as follows; taking the characters from a set of Persian cuneatic alphabet, arranged according to a recent interpretation, which happens to lie upon my table, and which, though imperfect, will answer the present purpose, as shown in the accompanying diagram.

It was evident that the first and second letters in the first name ought not to occur at all in the second. They did not. The third letter in the first name ought to be the fifth in the second name; and it was so. The fourth letter would not occur in the second name, but the fifth letter of the first name ought to be the fourth and the last of the second name; it proved to be so. The sixth of the first name would be absent in the second, but the final SCH of D A R Y E U SCH should necessarily

be both the second, on the last character but one in KH. SCH. H. E. R. SCH. E.; and it was so.

Thus was the first step in the interpretation of the cuneatic characters of the Persian system put to proof; and the result was acknowledged to be a brilliant discovery. in conse-



quence, however, of different methods being employed in the Persian system for writing the same words, the discovery was not entirely accurate, yet it was such a step as fairly led to the expectation that further progress would speedily follow. Yet such was not the case. So far and no further, with trifling exceptions, did the discoveries of the German scholar and his immediate successors extend; and for nearly half a century no

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further material progress was made. The whole of the great discoveries in Egyptian hieroglyphics, in short, took place before another great step in the reading of the wedge-shaped characters of Asia was achieved.

It was not, in fact, till the magnificent discoveries of Assyrian remains by Botta, and the subsequent researches of Layard, that Rawlinson, Lassen, Hinks, Norris, and other scholars, aided by recent progress in the knowledge of Sanscrit, Zendic, and other ancient Asiatic dialects, completely mastered the cuneatic characters of the Persian system; the intermediate labours of Millin, Rask, Bournouf, and St. Martin having led to no very material results.

Even now, the Assyrian and Babylonian forms of the cuneatic systems are but very imperfectly known, although the Persian may be said to be mastered. The earlier forms of cuneatic writing are, in fact, much more complicated, containing as they do a vast number of pictorial and symbolic characters, while the alphabetic or sound-expressing signs form only a supplemental part of those earlier systems. They have still also the old *determinative* signs of the Egyptian system, and are overloaded with many other incumbrances belonging to the pictorial and symbolic stage of the art of writing, which it will require much time to reduce to order, even after the principles are well understood. Nevertheless, passages of great historical interest have been read off by Rawlinson and other cuneatic scholars, with a very near approach to their general import, though minor details admit of much dispute. But we are on the eve of a final and perfect interpretation of the ancient records of the Asiatic empires; a result of modern scholarship which may throw new and entirely unexpected light upon the history of those regions.

INSECT VISION AND INSECT SLEEP.*

BY THE HON. RICHARD HILL.

I.—INSECT VISION.

November 24, 1860.—In setting up in a collection our several crickets, locusts, and grasshoppers, we see that there is a prevailing colour as marked and as intense in the eyes as in the body: thus, locusts are red; grasshoppers green; and crickets black; and their eyes are of similar decided hues. Are we to

* These notes have appeared in the pages of a journal which circulates only in the island of Jamaica; the author wishes them to have a wider publicity, and has kindly forwarded them to this work for that purpose.—Eds.

infer that objects to them have the same tint as these hues of the choroid? Are they coloured as we see landscapes to be when we look through a window of painted glass? Through the red, are objects beheld as if they were blazing in a fiery furnace; or do they appear as frigid as a snow scene in blue eyes as through the blue glass? Some purpose is served by the relation. Let us see, or let us make inquiry what it may be; if it ends in nothing certain, it will, at least, be attended with instruction and amusement.

In the solar spectrum, there are rays independent of those of light, which impart a sensation of heat. These calorific rays are most abundant a little beyond the red verge of the spectrum, and diminish gradually towards the violet. When it was observed, in the Conservatory at Kew, that plants suffered from the scorching influence of the calorific rays through the glass covering, a series of experiments were pursued to ascertain the possibility of cutting off the heat-imparting rays by means of tinted glass. A glass tinted of a pale yellow-green prevented the permeation of the heat rays to the maximum of the calorific action. The pinky hue of the light was modified, and the scorching influence subdued. What they sought to accomplish was effected. They obtained a properly moderated heat.

White is the simultaneous sensation of all the prismatic colours. By suppressing red, we obtain a bluish-green hue; by suppressing the blue and the green, we obtain an excess of yellow and red. The purest air, or clearest water, gradually extinguishes, by absorption, the rays passing through them. The lesser stars are visible on the loftiest mountains; but their lessened light hardly affects the sight in the stratum of the atmosphere at the depth of the plain below. The natural stimulus of the retina is the action of the luminous rays. Modifications are essential where the activity of perception may be allied to the conditions of diseased sight. "Many are the waves and coruscations—the fiery clouds and flaming spectra which haunt the amaurotic when certain morbid complications exist," and when the optic nerve is peculiarly influenced, a compensatory modification of the peculiarity in regard to tint is made by the adoption of coloured glasses for the sight. We may presume that what is in excess in the locust is modified by the red pigment of the eye, and what is superabundant in the grasshopper by the yellow and the blue.

The eyes of insects are what are called facetted eyes. They are cut in hexagonal compartments, and have the appearance and the power of multiplying glasses. The outer coat is composed of a thin plate, resembling horn. It is stiff but flexible, and compact but transparent. Immediately beneath each corneule or hexagonal compartment, that is, beneath the facets of

the outer covering of the eye, is a layer of colour. It covers the whole of the inner surface of the corneules, excepting only in the centre of each where a minute aperture is seen, admitting light by the iris. Between the iris and the end of the cornea is a space, flattened and convex, filled with an aqueous humour. Each convex lens corresponds with each facet. The rays of light passing through them fall upon a transparent space occupied by a vitreous humour. The choroid in the eyes of insects, like the choroid in the vertebrata, is the proper vascular structure of the organ of vision. The pigment of the choroid is subject to much variety of colour in different insects. In some it is nearly black, in others dark blue, violet, green, purple, brown, and yellow, and in some, two or three layers of pigment are of different colours. The usual arrangement of these variegated pigments is, first, a dark-coloured portion near the bulb of the optic nerve, then a lighter colour, and lastly, again, a darker near the cornea.

Puget adjusted the eye of a flea (*Pulex irritans*) in such a way as to see objects through it. On applying the microscope to the multitude of mirrors, nothing could exceed the singularity of what was seen. "A soldier appeared like an army of pigmies; for what it multiplied it diminished; the arch of a bridge exhibited a spectacle more magnificent than an edifice erected by human skill; and the flame of a candle seemed the illumination of a thousand lamps." The minute regularity of the objects in each of the facets, so disposed as to converge to a central ganglion, make but a single picture in perception. The great optic nerve uniting into a focal point the coincidence of what Dr. Wells designates "*the visual direction,*" impresses an image intensely concentrated. The perception of each impression being confined to that of the object immediately in a line with the axis of vision, the impacted lights and shadows of a thousand representations of one and the same form—the visual product of a thousand facets—give a stereoscopic representation under a thousand adjustments, and render the small organ of the small animal, in power and concentration, a microscope.

The successive zones in the insect eye modify the rays that penetrate the sight, passing by each facet, and by the centre of each converging cylinder radiating to the optic ganglion. The layer of pigment does nothing but diminish the quantity of light, and adjust it. It is found in most if not all *diurnal insects,* and the iris being perforated with as many holes as there are facets in the cornea, it is subjected to multiplied modifications. As might be expected, this pigment is not met with in any of the *nocturnal insects.*

Insects that fly require an ample field of vision. The combined corneules become one large pupil. The multiplied facets

render superfluous eyelids and muscles to move the eye. In consequence of the vision being directed to the whole circumference, it comprehends, by relative adjustment, all objects around. A simpler eye occurs in the grovelling insects that see only what is near with distinctness. In insects which fly by night, like the moths, there is, in place of the black or coloured pigment, a substance of a resplendent green, or silvery colour, serving not to absorb, but to reflect the rays of light, and enabling them to see by a more obscure illumination than that of daylight. The eyes of moths look always luminous, and appear as if they were phosphorescent, from this reflecting power. This organization gives a solution to the reason why moths fly to the candle. They lose all discernment in the blaze of radiance that overwhelms them by reflection; and they perish in the flame into which they rush.

After I had entered among my notes the preceding memorandum, I requested my friend, Mr. Toase, to verify for me Puget's examination of the facetted eye of an insect, by an inspection of the organ under his excellent large microscope. He kindly complied with my request, and sent me the following interesting letter:—

"Kingston, 21st January, 1861.

"My dear Sir,—I have taken a dragon-fly (*Libellula*) as the study of the eye of an insect. * * *

"The eye was first simply removed from the head of the dragon-fly and examined under a good lens:—seen thus, it seemed as if it were covered with intensely small drops of water, something like dew.

"The eye was next immersed in solvents, and cleaned with a fine camel's-hair brush, leaving nothing behind but the cornea. This to the naked eye had the appearance of a white transparent horny substance, having the form of a shallow cup.

"It was now placed under a microscope with a power of 250 diameters, or magnifying 62,500 times.

"Under this power the bead-like appearance, noticed with the simple lens, resolved itself into a definite form, resembling precisely the cells of the honeycomb as they appear on the broad plane. Like these cells, each division was hexagonal. The substance of each division was convex exteriorly. We are reminded that this is the form which economizes space the most, and that it is also the form always taken by the *equal* sized round bodies when *equally* pressed together. This law we see exemplified in the cellular tissue of plants, and we account for the elongated form of the cells of the fibrous tissue, by *unequal* pressure. We see this law in the formation of the cells of the honeycomb, as equally sized globular cells equally pressed *laterally* and forming hexagonal cells. We see it again, though imperfectly, it is true, in soap bubbles. Might we not, therefore, infer that this peculiar form is the natural effect of a known law, and that it could not assume any other form? But to remove all

doubt, we must prove our premises, that is, if the facettes of an insect's eye, composed originally of an immense number of spheres of equal size, equally pressed, laterally, pass into the hexagonal form, or suffer any other modification.

"That they are of equal size is manifest from simple inspection.

"We will now see if experiments prove they are, or have been, spheres; but I must first speak of some further examination of the cornea.

"I counted the number of facettes, or faces, by the micrometer, and found in each eye 12,500, but I think they are somewhat more numerous.

"Around each facette I found a fringe of fine hairs, which seem to fulfil the purpose of eyelashes.

"I now placed the cornea in such a manner, that, in looking through the microscope, and *through* the cornea, I could see the flame of a candle. I then saw, not one flame, but an immense number of flames; in fact, an illumination of candles on a large scale, which arrangement quite corresponded with the hexagonal form of the facettes: thus there was a row of flames, and above this another row, not one flame above another, but intermediate flames in intermediate rows, and so on one row with another.

"Each facette is then a distinct eye, producing a distinct image in each facette.

"An ordinary observer might infer that the insect saw not one object, but a multitude of objects; not one flower, but thousands, producing a complete 'embarras de richesses,' most confusing to the poor fly. It is natural that we should be led to such a conclusion. But, on the other hand, we are taught by analogy that 'order is Nature's first law.' To help us to the clue of this second point, or of this apparent confusion, we will continue our experiments.

"Taking for granted that spheres were upon the disk, I severed them with a needle and found one end of the several pieces circular, and the other pointed; in fact, each separate ocellus, or eye, had the form of a cone, the basis forming the facette, and the apex converging to a centre. Each was embedded in a mass of pigment—in plain terms, black paint; with each apex receiving a filament of the optic nerve. Each separate ocellus, therefore, has a separate power of vision.

"Each facette, cone, and filament being separated from all other facettes, cones, and filaments by a layer of pigment, forms a separate ocellus, so circumstanced that no ray of light received by one passes into another, and all the filaments being severed from each other by the pigment, they in no way interfere with one another.

"We now see, by experiment, that as each ocellus takes up a distinct picture, each picture is, necessarily, slightly altered in perspective. The images, by the direction of the facetted mirrors severally, are each slightly varied; but being united on the central ganglion, they form one perception of one object, or one scene. This is only a multiplication of the incidents of our own vision with two eyes. If we close one eye, we see an object in a certain perspective; if we close that eye that was open, and open that which was shut,

we see the same object in another perspective; yet if we open both eyes we do not see two images of the same object in different perspectives, but only one object in proper visual union by coincident perception.

"The moveable eyes in ourselves, and the immoveable eyes in the insect, do not affect this analogy. The multitude of facettes accommodate the immoveable eyes to a whole panorama. The stereoscope will illustrate all the facts in both circumstances of vision. In the stereoscope we have exhibited to us two representations of the same object in different perspectives:—the difference corresponds with the distance between the two lenses through which we are looking; they are both immoveable, but visually combined they are but one perception of one and the same object. In the same way insects, with their multiplied incidents of vision, see by coincidence but one representation from a multitude of eyes.

"I trust, my dear sir, I have met your purpose in testing Puget's experiment.

"Believe me, etc., "THOS. D. TOASE."

II.—THE SLEEP OF INSECTS.

The ocelli, or secondary eyes of insects, which Linnæus regarded as a kind of coronet, and called *stemmata*, and which Reaumur conceived were designed for that near vision, which the primary eyes, by their immoveable structure, could not accomplish with proper distinctness, have, I have but little doubt, by the experiments which have been made on vision, and on the excitement of sleep, a very important influence in determining somnolency in insects. The vast field of objects commanded in vision, without the concentration of attention, is one of variety, but not of accuracy. In insects there is no dilation or contraction of a pupil to accommodate the sight to the circumstances of light and darkness. By attention we are conscious of perception. If the attention be limited to one point of a landscape, it sees only the objects *there*, and though there be visual impressions, there are no visual perceptions, where the mind is not attentively absorbed on what it is looking at. It is without the consciousness of seeing.

How do insects, with their great orbicular eyes always exposed to external stimulants, sleep? Sleep, like the inclination for food, is periodical. The habit in the lower animals is the alternation of light and darkness, in the degree in which one indicates day and the other night, for in a total eclipse birds retire to roost, and the diurnal insects resort to repose, and the nocturnal awake.* The influence that tends to wakefulness or

* Sir Hugh Lyon Playfair, in his lectures on the application of physiology to the rearing of cattle (Lect. 2nd), gives a very remarkable illustration of the influence of rapid alternations of light and darkness, without reference to the diurnal revolutions of the earth, in inducing sleep and inclination for food, in the Italian mode of rapidly fattening ortolans. At a certain hour in the morning, the keeper

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to slumber is the condition of the nervous system. If its functional activity be protracted, the vision gives way under the exhaustion of the nervous powers. If the action of the mind be purely intellectual, if the feelings be not excited under that action, the waste sensorially suffered is to be repaired by sleep, and the sensation of slumber becomes uncontrollable. The demand for sleep is the desire to have it; and whether the absence of sensorial impressions results from the settling of the mind to rest, or whether it be that darkness cuts off all stimulation from light, or silence conduces to repose, sleep is induced by the cessation of all visual or emotional excitement. If the mind be withdrawn from the consciousness of it own operations, or if it be acted upon by a monotony that either wearies attention, or distracting it, leaves the sensorial image without perceptive impression, the result is slumber, or the nervous relaxation of sleep.

> "Tir'd Nature's sweet restorer, balmy sleep!
> He, like the world, his ready visit pays
> Where fortune smiles;—the wretched he forsakes."
>
> YOUNG'S *Night Thoughts.*

When the mind divides itself between the thoughts and the emotions, mental activity being unsuspended and the feelings unappeased, the restlessness of anxiety becomes the inquietude of wakefulness; and though there be weariness of both heart and soul, the balm of slumber may be desired, but tired Nature remains ungratified by the restoration of sleep.

Having thus indicated the circumstances under which beings slumber, that combine an intelligent nature with a sensational one, let us examine *how* insects sleep.

When the senses are blunted to external impressions under the lessened excitability of the mind, and our ideas, more confused than vivid, are carried beyond ourselves in time and place, we instinctively lie down to repose. All the creatures organized with eyelids close the eyes against the influence of light. The temperature of the body sinks, owing to diminished nervous energy, and we seek with soft things to rest upon,

of the birds places a lantern in the orifice of the wall, made for the special purpose of darkening and illumining the room. The dim light thrown by the lantern on the floor of the apartment induces the ortolans to believe that the sun is about to rise, and they wake and greedily consume the food upon the floor. The lantern is withdrawn, and the succeeding darkness acting as an actual night, the ortolans fall asleep. During sleep, little of the food being expended in the production of force, most of it goes to the formation of flesh and fat. After the birds have been allowed to repose for one or two hours to carry on digestion and assimilation, the keeper again exhibits the lantern through the aperture. The mimic daylight awakes the birds again; again they rise and feed; again darkness ensues, and again they sleep. The representative sunshine is made to shed its rays four or five times every day, and as many nights follows its transitory beams. The ortolans thus treated become like balls of fat in a few days.

warm things to cherish us with heat, and then we go to sleep. The lower animals instinctively do what we do, though each accommodates itself differently. The horse will sleep standing in the warm shelter of the stable, though it lies down in the pasture; the bird reposes perching, but with its head buried in the feathers of the wing; the serpent coils itself in a circle, or folds itself into the smallest possible space; the fish screens itself in the weeds, or buries itself in the sand or in the mud of the stream; the insect withdraws from the scenes of its ordinary activity, and is in a state of somnolent rest, when it remains motionless. As the insect has no eyelids, no external closure of the eye gives evidence of sleep.

As all the physiological facts of sleep in the vertebrate animal coincide with effects exhibited by the heart and brain, and as insects have neither of these organic centres, then sleep cannot be induced by any peculiar change, either in lessening or quickening the flow of blood from one extremity to the other, but must result solely from the quietude of the senses, and from electrical incidents externally. Monsieur Cabanis, in his *Rapports du Physique et Moral*, has observed in man that some of the members and senses go to sleep sooner than others. He assigns the soporific influence sensationally to fatigue. The part first feels drowsy in which the flow of the blood is affected. Among the senses, the eye is the first that goes to sleep; after it, the smell, taste, hearing, and touch become successively drowsy. The touch is never entirely insensitive. The sight is more difficult to awaken than the hearing; a slight noise will rouse a sleep-walker who had suffered light upon his unshut eyes without any apparent influence; but insects, if affected at all internally, are very little affected in this way.

The insect world are acutely acted upon by atmospheric circumstances. Rain or cloudy weather operates upon them like a continuance or recurrence of night. It is not the warmth or the dryness of the air, its humid state or its coldness; it is the electrical condition that affects them. The constant alternations of sleep and waking, in whatever way they may be induced by repose or affected by functional activity, are regulated as periodical recurrences by the electrical laws of the seasons, by the reiteration of day and night, by the daily variations of the barometer, and by the conditions that move the magnetic needle from east to west at stated hours every day. Extreme weariness will prevent sleep if fatigue is unaccompanied by powerless attention and unsettled sensation. Let us see how these known facts may serve to explain the sleep of insects.

We shall comprehend some of the physiological incidents of slumber by attending to the processes of mesmeric sleep, as developed by Mr. James Braid in his work on Neurypnology,

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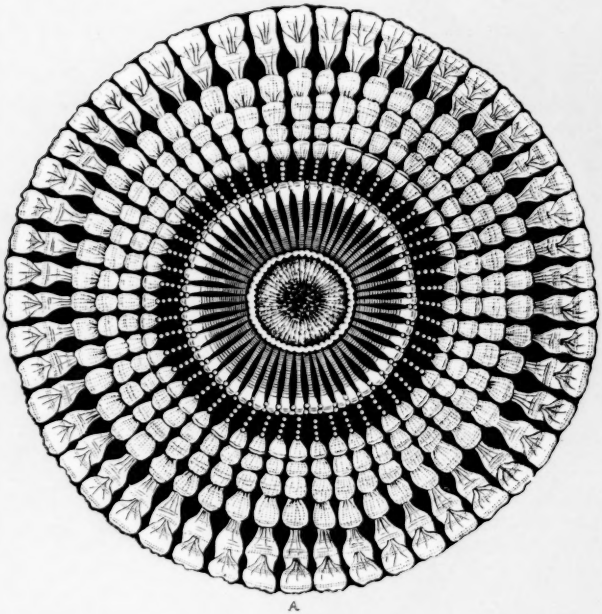
or the *rationale* of nervous sleep, in relation with animal magnetism. I would be brief with my extract, and yet I can scarcely venture to abridge his language. He says he induced cataleptic sleep, which he designates hypnotism, by keeping the eyes fixed on an object, and the mind rivetted on the idea of *that* one object. He so regulated the distance of it from the sight as to produce the greatest possible strain upon the eyes and eyelids. "It will be observed," he says, "that, owing to the consensual adjustment of the eyes, the pupils will be at first contracted; they will shortly begin to dilate; and after they have done so to a considerable extent, and have assumed a wavy motion, the eyes will close involuntarily with perceptible vibrations. Ten or fifteen minutes elapse, and the arms and legs are found disposed to be retained in the position in which they are placed. If the patient has not been so intensely affected as this implies, then, if he be spoken to in a soft tone of voice, and desired to retain the limbs in that or in an extended position, the pulse will speedily become greatly accelerated, and the limbs involuntarily fixed. It will now be found that all the organs of special sense, excepting sight, including heat and cold, and muscular motion and resistance, and certain mental faculties, are at first prodigiously exalted. It is such an exaltation as happens with regard to the primary effects of opium, wine, and spirits. After a certain point, however, this exaltation of function is followed by a state of depression far greater than the torpor of *natural* sleep. From the state of the most profound torpor of the organs of special sense and tonic rigidity of the muscles, they may at this stage be *instantly* restored to the *opposite* condition of extreme mobility and exalted sensibility, by directing a current of air against the organ or organs we wish to render limber, and which had been in the cataleptiform state. By mere repose the senses will speedily merge into the original condition again." Now, none of these processes, in inducing sleep, would be applicable to insects whose eyes are immoveable, if the provision for seeing was confined to the two large globular eyes on each side of the head; but being provided with ocelli, or auxiliary eyes, placed on the vertex of the head, these facts illustrate the drowsy insect. The structure of these auxiliary organs is just that of one of the lenses of the compound eye, but being so placed that they can be set close to what they examine, and can concentrate the attention to the exclusion of the objects that occupy the globular facetted eyes, it is possible that such visual concentration, when the insect retires to repose, induces just that perceptive vibration described in cataleptic sleep by which slumber can be brought on.

An insect composes itself to sleep with its antennæ folded. Some of the beetles adjust them to their breast; the butterfly



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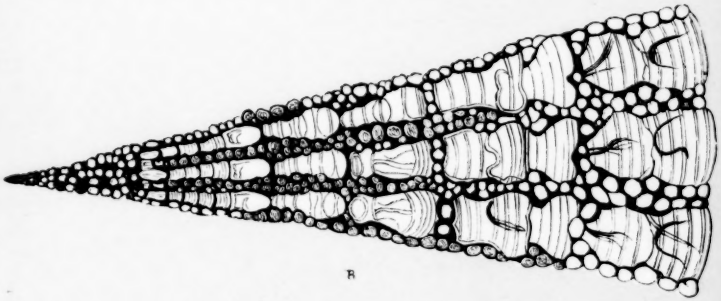

B.

A.—Echinus spine, (transverse section.)
B.—Portion of ditto more magnified, (differently illuminated.)

seeks some particular aspect of a tree, and folds vertically its wings, throws back the antennæ, and remains motionless and insensible to all external circumstances. When caterpillars, which are insatiable feeders, are observed resting immoveable with their heads bent down, they are asleep. The geometers may be remarked stretched our for hours projected from a twig resembling the angular stem of those trees they are feeding upon, and the processionary caterpillars, whose night marches, in marshalled communities, are regulated with such remarkable exactness, that they resemble battalions platooning over a field, in "strict love of fellowship combined" in passing the day in inaction, spend it in repose.

Whatever may be the controlling cause that renders some insects diurnal feeders and flyers, and some nocturnal and crepuscular movers, frolicking or feasting in the twilight, the solution must be sought in the adaptive differences that regulate the "*sleep of plants.*" Some plants repose by night; others expand in the darkened hours, and slumber under the stimulation of light. Whether the closing of the flower be at nightfall, or its opening be as soon as daylight fades, or whether it be the reversal of this order, the differences are precisely the same as in those animals that sleep through the day and awake at night, or that awaken in light and slumber in darkness. The regular intervals that lead to sleeping or waking are the recurrences of those *electrical* incidents that attend the interchanges of day and night in the atmosphere.

ON THE APPLICATION OF THE MICROSCOPE TO THE ART OF DESIGN.

BY HENRY J. SLACK, F.G.S.

MANUFACTURING experience affords many instances of surprising success achieved by ornamental goods, whose patterns were judiciously selected from natural objects; but although examples of various combinations of form and colour occur in great profusion in those portions of the natural world which are accessible to unassisted sight, the microscope constantly presents us with a rich store of ideas which the decorative artist would do well to study and employ. If colour be the especial subject of his pursuit, the wings of butterflies or the wing-cases of beetles, the petals of flowers—such as London-pride—minute sea-weeds, and other common objects, are highly instructive; and if we were requested to point out an illustration of the union of extraordinary splendour with grateful

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repose, we could not do better than refer to the armour in which the diamond beetle is arrayed. When Mr. Owen Jones completed his "Alhambra Court," at the Crystal Palace, every one was struck by the mingled softness and gorgeousness of the aspect. The eye could look steadily without being wearied, while a visit to the House of Lords, when its colours were new and fresh, afflicted observers with an unpleasant sense of tension, rapidly followed by weariness, from which there was no escape. Even in the cases of persons afflicted with colour blindness, we sometimes find that what may be called colour discords are productive of disagreeable impressions, while colour harmonies, although only partially perceived, call forth pleasurable emotions.* Still more striking are the effects of colour harmonies and discords upon individuals whose physical and mental organs are in a sound and cultivated state. They are not satisfied with the mere avoidance of mistakes, or with the presentation of the most elementary concords which pigments can produce. Their tastes lead them to desire to untwist all the chains of colour harmony; they love the complicated effects of tertiary combinations, and are discontented with brilliance if it be destitute of repose.

What constitutes repose in colour is a difficult question, but it is probably connected with the physical action of different kinds of light on the optic nerve. Red, blue, and yellow, in the proportions which theoretically produce white light, are agreeable; but not exclusively so, and nearly all the modifications of prismatic colour obtained by means of crystals and the polariscope are satisfactory in a greater or less degree to the eye. It naturally follows that the more vivid the light emanating from coloured bodies, the more strikingly the defects of harmony are disclosed, and although there are many cases in which brightness and intensity become sources of a high degree of pleasure, they are not unfrequently productive of sensations akin to pain. In the scales which adorn the diamond beetle, the lustre, under good illumination, is nearly equal to that of the most brilliant gems, and yet the eye can rest upon it without fatigue. An attentive observation will show how this depends upon the juxtaposition of cool and warm tints, the gorgeous yellows and orange chromes being relieved by a due proportion of blues and greens. Diamond beetle colours are not wanted in large masses, but the first manufacturer who composes them into a border, whether it be for porcelain or a textile fabric, with a warm chocolate ground, can scarcely fail to be rewarded for his pains.

* This is not an imaginary case; the writer knows a gentleman to whom no colour appears as it does to other people, and who is apparently insensible to pure red rays, but who is much annoyed by many colour discords, and able to arrange a nosegay so as to produce an agreeable effect.

Before leaving the subject of microscopic colour study, let us point to the use of the polariscope for observations, which no other method can place so readily within reach. It is usual to display polarizing objects in their most striking situations, when they present contrasted masses of pure prismatic colour. From these, however, the decorative artist will learn little; but if he takes a concentrated solution of nitre, or tartaric acid, and allows a drop to crystallize rapidly on a warm slide, he is tolerably certain to obtain his material in such forms, and in such varying thicknesses, as will enable him to produce a number of interesting tertiary combinations, by adjusting the polarizing and analyzing prisms to the best positions for the particular effect desired. These experiments require a selenite stage, and the means of rotating *both* prisms, and not the polarizer only, as is the case with the arrangements that some opticians send out.

For a combination of green tints and forms, adapted to the jeweller and enameller, the desmids may be recommended, of which some useful specimens are figured in *Recreative Science*, vol. ii. p. 279. The beautiful fluted and otherwise marked bottles of the Foramenifera fern, called Lagenæ, would furnish classical patterns for the glass-blower, and his attention should likewise be directed to the polycystina from Barbadoes, whose siliceous shells of varied shapes glitter like the finest crystal when lit up by the dark ground illumination which the parabola affords.

Another class of objects that merit attention for the suggestions they afford, are the spines of the echinus, or sea urchin. The sea urchins belong to the *echinodermata*, or "hedge-hog skinned animals," a class which comprehends star-fishes, sea hedge-hogs, or urchins, and those curious creatures the sea cucumbers. Many readers will be familiar with Edward Forbes's classical work, entitled "British Star-fishes;" but for the benefit of those who do not know his remarks on the urchins, we may state that in one of moderate size he found 3720 pores arranged in ten series, or "avenues," with one sucker to every two pores. Their shells are composed of nearly 600 angular pieces fitted together like a mosaic, each plate being enveloped in the lining membrane, by which it was deposited, and which provides for its growth. These plates are furnished with about 4000 spines, every spine being built up of a multitude of pieces deposited by a living tissue, and producing a radiating pattern as shown in the tinted plate, which has been engraved from a drawing by Mrs. Henry Slack. Fig. A represents a thin section of an usually beautiful spine, illuminated by a unilateral slanting light, arranged at such an angle as to mass certain portions together in solid diverging rays. Fig B gives a truer idea

of the minute structure ; but A is far more suggestive for the purposes of decorative art. It only requires reducing to strict symmetry to supply an idea for an oriel window, a tesselated pavement, or the centre of a plate. A slight change in the angle of the illuminating pencil, coupled with an increase of its brilliancy, produces a splendid effect at night. The solid-looking rays shine with a lustre between that of glass and gems, while the more transparent portions assume a pearly or a silvery hue. In this state we have suggestions for a star of an order of knighthood, or a superb brooch. With the echinus spine, as with other objects adapted to our present purpose, the decorative idea varies with the mode of illumination, and that which is best for artistic effect is not always the most desirable for a scientific analysis of the structure. A complete set of these experiments requires a good microscope, furnished with a Lieberkuhn and dark cells, a side silver reflector (which had better be on a separate stand), and the parabolic illuminator, with all of which the object should be tried. It is also imperative that the mirror under the stage should be mounted upon an area capable of throwing it out of the perpendicular plane of the instrument, and that the aperture of the stage should be large enough to admit light sufficiently oblique to produce the effect of a dark ground.

We may refer, in concluding these brief remarks, to the compound polyps, and the polyzoa, so common on our coasts, and which can scarcely be excelled in beauty when properly shown. A small sketch of the *Laomedea geniculata* is given in p. 131, vol. iii., of *Recreative Science*. When living, the tentacles resembled pendants of frosted glass, the cells were clear crystal goblets, and the stalks of a horny texture and colour. From these polyps a clever designer could easily have devised a pattern for an epergne, a portion of a border for a tesselated pavement, or a figure for a sitting-room paper or a lady's dress. The rational use of such objects cannot be attained by mere imitation, but through the apprehension of a principle or an idea, and its reproduction according to the purpose of the manufacturer and the laws of decorative art.

THE COMMON LIVER ENTOZOON OF CATTLE.

BY T. SPENCER COBBOLD, M.D., F.L.S.,
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If the attractive-looking amphistome, figured from Blanchard, and described in the preceding number of this periodical, has excited a desire for further information on "parasites not generally understood," the writer is confident that the more familiarly known creature whose portrait is annexed, will be found worthy of the most attentive consideration.

This little entozoon, more powerful for the destruction of its friends than are our huge armaments for the annihilation of our enemies, destroys in England alone some tens, and even hundreds of thousands of sheep annually, besides afflicting in a lesser degree the larger cattle;* added to which, our own *viscera* are sometimes deemed worthy of a visit; though, happily, this is of extremely rare occurrence. Obviously, therefore, the naturalist who shall be able to point out any means whereby the ravages of the common liver fluke may be frustrated, will confer a great boon on society at large, and more especially on agriculturists and cattle-breeders, who are most nearly interested in the welfare and preservation of their flocks.

On more than one occasion the writer has sought to convey to the parties above mentioned accurate intelligence as to the mode in which the liver flukes gain access to their *hosts*, or, in other words, to the bodies of the herbivorous quadrupeds they infest; but, as happens too frequently in such cases, he has found the vague opinions of a bygone age deemed more worthy of credit than the clearly enunciated facts of recent scientific discovery. When a still brighter light, however, shall have brought to view all the missing links now wanting to complete the chain of evidence, the promoters of science will more hopefully seek to enlighten those who, in so far as *natural* knowledge is concerned, are unwisely clinging to the "tales of a grandfather."

* Lest the writer may be thought to exaggerate the numbers here spoken of, he begs to call attention to an extract from that trustworthy and admirably conducted northern journal, the "Edinburgh Veterinary Review." At p. 63 of last year's volume the following passage occurs:—"In England this scourge of the ovine race has occasionally reduced the number of sheep so much as to materially enhance the price of healthy animals. For instance, in the season of 1830-31, the estimated deaths of sheep from rot was between 1,000,000 and 2,000,000. By supplying turnip, oleaginous cakes, and grain, sheep partially affected can be fattened; and those not affected can be kept sound by a limited daily allowance of one or other of these foods." Supposing the number to have been 1,500,000, this would represent a sum of upwards of £4,000,000!

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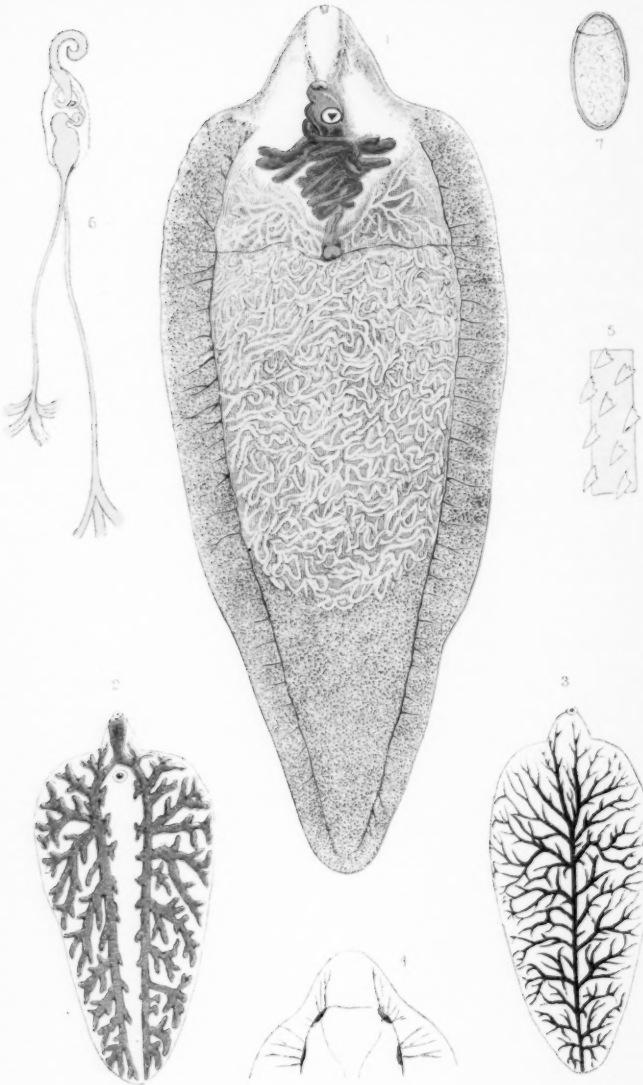
The general reader and the accomplished scholar are probably little aware of the extreme difficulties which attend experimental investigations into the modes of reproduction found to obtain in entozoic life, and yet it is by these artificial means alone that practical science can successfully carry out its benevolent purposes. If conducted properly, the necessary experiments not only require time and the sacrifice of personal interests; but, in addition, a special supply of funds for the purchase of the larger animals to be operated on. In this country, such grants from governmental sources are not usually entertained, but on the continent—in that despised little kingdom of Saxony, for example—we find a ready hand tendered to the indefatigable cultivators of helminthological inquiry. One of the foremost of these is Dr. Frederick Küchenmeister, of Zittau, who, in the preface to his well-known work on human parasites, says, "The animals employed in experiments by myself, and at my own cost, were rabbits, cats, dogs, and a few sheep. The greater number of the pigs and sheep thus bestowed were procured at the expense of the Saxon ministry of the interior, by Professor Haubner, of the Veterinary School at Dresden; a considerable number of sheep being also provided at the expense of the Agricultural Society of Saxon Lusatia, and by the kindness of individual landowners."

In England the Royal Society and the British Association, following the example of the Parisian Academy of Sciences, have frequently devoted small sums to private investigators and dredging committees, for the judicious purpose of forwarding researches of a more or less purely scientific character; and it would be gratifying to hear that other public bodies had volunteered similar assistance to independent workers whose pursuits embrace more practical aims, and whose discoveries could not fail to benefit the community at large. The subject matter under consideration is one of those in which much still remains to be accomplished; but, before pointing out the special requirements of the case, the writer requests attention to the following ascertained facts respecting the structure and habits of the common liver fluke of sheep and cattle.

This entozoon has been known from the earliest times, and the animal may almost be said to have acquired a literature of its own. However, as regards the obscure opinions formerly entertained concerning it, little, perhaps, need be said; but those who may desire a list of references are invited to consult the author's *Synopsis of the Distomidæ*, quoted on a former occasion.

The scientific names of this parasite involve a question of some importance. Amongst naturalists generally it is continually spoken of under the combined generic and specific titles



Fasciola Hepatica.

of *Distoma hepaticum;* but working parasitologists, who are at the same time acquainted with the writings of the earlier scientific observers, know very well that these titles are both incorrect and inappropriate. The proper generic appellation of this parasite is *Fasciola,* as first proposed by the illustrious Linnæus (1767), and subsequently adopted by F. Müller (1787), Brera (1811), Ramdohr (1814), and others. Unfortunately, however, Retzius (1786) and Zeder (1800) changed the generic title without good cause, and the majority of writers, following their authority, obstinately refuse to employ the original name, although fair dealing with the posthumous reputation of its distinguished author, and a consideration of the distinctive types of structure displayed by the two genera (*Distoma* and *Fasciola*), alike demand the retention of the Linnæan title. In later times, M. Emile Blanchard (1847), of Paris, has strongly advocated the final adoption of the Linnæan nomenclature, and the writer himself has also from time to time (in 1854,-56,-58, and 1860) demonstrated the propriety of rejecting the commonly received synonym. Another distinguished French naturalist, namely, Professor Moquin-Tandon, has also employed the term *Fasciola,* but by placing in the genus several species not properly belonging to it, such as *Distoma lanceolatum* and *D. heterophyes,* he has unwittingly rendered "confusion worse confounded."

The *Fasciola hepatica* is not only of frequent occurrence in all varieties of grazing cattle, but has likewise been found in the horse and ass by Daubenton; also in the hare and rabbit by the writer himself and others, in the squirrel by Tozzetti as previously mentioned, in the great kangaroo (*Macropus giganteus*) by Bremser and Diesing, in various antelopes and deer by Pluskal, etc., and also in the beaver (*Castor fiber*) by Czermack. Its occurrence in man has been recorded by Pallas, Bauhinus, and Bidloo, doubtful instances being also given by Mehlis and Duval. More recently, Professor Partridge of King's College detected it in the human gall-bladder, particulars of the case being described in the second edition of Dr. Budd's well-known treatise on "Diseases of the Liver." Giesker of Zurich mentions an undoubted example where the Fasciola had lodged in the sole of a woman's foot, whilst a similar case came under the observation of Mr. Fox of Topsham, Devon, the entozoon being located beneath the skin, about three inches behind the ear. Mr. Harris of Liverpool has likewise related an example where six or seven flukes had apparently penetrated the scalp of a little child, and there is every reason to believe that all these entozoa are referable to the species under consideration.

If attention be directed to the accompanying coloured plate, it will be noticed that the central figure, copied from Blanchard, exhibits the ventral surface of the *Fasciola hepatica;* and, as

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the animal seldom attains the length of an inch, this drawing (fig. 1) represents an ordinary specimen magnified about six diameters linear. To the naked eye the skin appears smooth, but microscopic aid shows the cuticle to be furnished with numerous rows of minute pointed spines (fig. 5). In the Amphistome we find two pores, one at either extremity of the body; but in the genus Fasciola, as also obtains in the majority of flukes, the oral and ventral suckers are more nearly approximated. The latter pore is frequently termed the *acetabulum*, and in the illustration before us it is seen occupying a median position at the base of the neck. It does not communicate with any cavities internally, and is simply employed as a "holdfast." The oral sucker forming the mouth leads to the short œsophagus, which very soon divides into two primary stomachal or intestinal trunks, which latter in their turn give off branches and branchlets; the whole together forming that beautiful dendritic system of vessels which has often been compared to foliar venation. This remarkably formed digestive apparatus is accurately represented in the annexed diagram (fig. 2), which should be contrasted with the somewhat similarly racemose character of the water-vascular system, shown on the opposite side of the plate (fig. 3). Let it be expressly noted, however, that in the digestive system the majority of the tubes branch out in a direction obliquely downwards, whereas those of the vascular system slope obliquely upwards. A further comparison of the disposition of these two systems of structure with the same systems figured and described as characteristic of the Amphistome, will at once serve to demonstrate the important differences which subsist between the several members of the two genera.

These distinctions stand out with equal cogency if we carefully examine the arrangements of the complicated reproductive apparatus; and here again the colours introduced into the plate at once enable us to institute a new comparison, and at the same time supersede the necessity of an otherwise extended description of the parts. All the orange-yellow-brown masses, with their delicate, connecting, dark coloured lines belong to the female division of the reproductive elements of this hermaphroditic species; the dark, central mass of folded tubes being the combined uterine cavity and oviduct, in which the eggs complete their final stage of development, before they gain access to the outer world. The multitude of little botryoidal organs occupying the sides of the body, and all that part which may legitimately be called the tail, are the so-called yelk-forming glands, and it will be observed that they communicate with the above mentioned oviducal, uterine folds, by the intervention of two common ducts, which run transversely in-

wards from either side, and meet together in the middle line. The canals in question convey the yelk-granules, which are formed in this curious set of organs, specially developed for their secretion in the flukes. The terminal portion of the male reproductive apparatus (fig. 6) is not unlike that of the Amphistome, the *vasa deferentia* uniting to form a sac, which is lodged within a sheath-like pouch; the latter embracing the lower part of the spirally protruded intromittent organ. The testes, instead of displaying the simple lobular character seen in the Amphistome, are split up, as it were, into tortuous bands, the two glandular masses together occupying the centre of the body. According to Blanchard, the glands are intimately blended with one another, and he also recognises the existence of a third duct, which he represents as connected with the shorter *vas deferens*. Be that as it may, the extent and complication of these organs are sufficiently calculated to excite astonishment; whilst, at the same time, they afford a very fair criterion of the reproductive powers enjoyed by this group of animals. The eggs are a trifle larger than those of the Amphistome, the chorion or shell being of a yellow-brown colour (fig. 7), and provided with a lid to facilitate the escape of the enclosed ciliated embryo. The nervous system consists of two cerebral lobes, one on either side of the oral cavity, and of a series of feebly developed ganglia, connected to the former by continuous filaments (fig. 4). Only two or three pairs of ganglia have as yet been indicated, but the filaments have been traced on either side of the body, to within a short distance of the caudal extremity. Küchenmeister altogether denies the existence of a nervous system in the fluke; but he is obviously unacquainted with the original discoveries of Mehlis and the subsequent descriptions of Otto and Blanchard.

Turn we now to the consideration of the habits of *Fasciola hepatica*, which, in so far as they relate to the excitation of the liver disease in sheep, acquire the highest practical importance. Intelligent cattle-breeders, agriculturists, and veterinarians have all along observed that the *rot*, as this disease is called, is particularly prevalent after long continued wet weather, and more especially so if there have been a succession of wet seasons: and from this circumstance they have very naturally inferred that the humidity of the atmosphere, coupled with a moist condition of the soil, forms the sole cause of the malady. Co-ordinating with these facts, it has likewise been noticed that the flocks grazing in low pastures and marshy districts are much more liable to the invasion of this endemic disease than are those pasturing on higher and drier grounds; a noteworthy exception occurring in the case of those flocks feeding in the salt-water marshes of our eastern shores. The latter circum-

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stance has suggested the common practice of mixing salt with the food of sheep and cattle, both as a preventive and curative agent; and there can be little doubt that this remedy has been attended with more or less satisfactory results. The intelligible explanation of the good effected by this mode of treatment we shall find to be intimately associated with a correct understanding of the genetic relations of the entozoon in question, for it is probable that the larvæ of *Fasciola hepatica* exist only in the bodies of fresh water snails or small aquatic animalcules.

It is not intended in the present communication to offer a lengthened account of the various discoveries and facts which enable us to make this last-named statement; but correlating all the known data afforded by the experience of the parties above mentioned, by observant naturalists, by our own researches, and more particularly by the recent experimental investigations of continental helminthologists, we shall provisionally state in a tentative manner the conclusions to which a due consideration of all these facts inevitably lead. The deductions here recorded may eventually require modification in respect of their minor details, but in the main they will be found substantially correct, and therefore be likely to convey that kind of information which can scarcely fail to interest those more immediately concerned in the preservation of cattle:—

1. The *Fasciola hepatica*, or sexually mature liver-fluke, is especially prevalent in sheep during the spring of the year, at which time it constantly escapes from the alimentary canal of the *host*, and is thus transferred to open pasture-grounds.

2. It has been shown by dissections that the liver of a single sheep may, at any given time, harbour several dozen specimens of the fluke, and it is certain that every mature entozoon will contain many thousands of minute eggs.

3. The escaped flukes do not exhibit powers of locomotion sufficient to prove them capable of undertaking an extended migration, but their movements may subserve the purpose of concealing them within the grass or soft soil where they have fallen. Their habit of coiling upon themselves probably facilitates the expulsion of their eggs.

4. The eggs can only escape from the oviduct of the entozoon one at a time, but there is every reason to believe that large numbers of loose ova are expelled from the infested sheep in the same manner as the flukes themselves.

5. By the dispersing agency of winds, rains, insects, feet of cattle, dogs, rabbits, and other animals, and even by man himself, the eggs are carried in various directions, not a few of them ultimately finding their way into pools, ponds, ditches, canals, and running streams.

6. The freed eggs, if mature, contain ciliated embryos, capable of active progression when brought in contact with dew on the blades of grass, rain-drops, pools of water, ponds, and lakes. The prolonged action of moisture without, aided by vigorous movements of the perfected embryo within, serves to loosen the lid-like end of the egg-shell, by the opening of which the animalcule is set free.

7. The ciliated embryo, or *proscolex*, as Van Beneden calls it, contains within itself a solitary germ, which is developed by a process of internal budding into a non-ciliated larva, or *scolex* in the language of the Louvain Professor.

8. The ciliated embryo, after swimming about for a time, sooner or later selects and attaches itself to the surface of the body of a pond-snail, a slug, or the soft body of some aquatic insect. In this situation it looses its ciliated covering, and subsequently gains access to the interior of the selected *host*.

9. Once within the viscera of its *host*, the embryo disappears, leaving the hitherto contained germ-bud, or *scolex*, to undergo its further development, which is accomplished rapidly, a second progeny being at the same time formed within its own interior.

10. The enlarged and independent scolex is now transformed into a large sac, or cyst, for the support and protection of its contained progeny. In this condition it is frequently called a "Nurse," or "Sporocyst," and when rather highly organized, is known by the title of "Redia."

11. The nurse-progeny, or trematode larvæ, thus produced within the scolex, are usually furnished with tails, and when fully developed are the well-known Cercariæ. Van Beneden calls them *proglottides*, but the term is inappropriate.

12. The Cercariæ have a tendency to migrate from the bodies of their molluscan or insect *hosts*, and they are quite capable of an independent existence. During these wanderings in the water, or in moist pastures, they are occasionally brought in contact with the human body, and, in a few instances, appear to have succeeded in penetrating the skin.

13. It is not certain whether the Cercariæ are taken into the bodies of quadrupeds when the latter are drinking water or eating solid food, but it is probable that they are transferred in either way. It is not unlikely that they are often swallowed while still within the bodies of their molluscan or insect *hosts*.

14. From the digestive organs of the sheep or cattle the Cercariæ bore their way through the tissues into the liver, in which situation they part with their tails, and become encysted. This constitutes the so-called *pupa* stage.

15. The pupa, thus encysted for many weeks, or even

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months, attains a higher organization, at last becoming converted into the sexually mature *Fasciola hepatica*. It then gains access to the liver ducts, passes into the common biliary outlet, or *ductus choledicus communis*, from thence is transferred into the intestinal canal, being finally expelled from its vertebrate *host* in the manner previously described.

If due consideration be awarded to the conclusions above given, it will at once be perceived that the multitude of remedies which are daily administered to sheep for the cure of the *rot*, or *cachexia aquosa*, can prove of little avail. Every year we hear of the adoption, often with enthusiasm, of new so-called specifics, or of ancient medicines whose employment had long fallen into desuetude. Thus, for example, in the April number of the *Journal des Vétérinaires du Midi* for 1860, we find M. Raynaud strongly recommending soot, in doses of from one to three spoonfuls, to be followed up by the administration of a grain of lupin for tonic purposes. In like manner we have received from France wonderful accounts of the medicinal virtues of a certain fœtid oleaginous compound, the value of which has been lately put to a fair test by our distinguished veterinarian, Professor Simonds. This last-named gentleman having with infinite care and trouble undertaken a series of experiments with the nauseating remedy in question, informs us, in the *Scottish Farmer and Horticulturist*, as a result of his inquiries, that he fears "we must conclude that this supposed cure of *rot* in sheep has proved quite ineffective for good in our experience."

It is not now proposed to enter into details respecting the genetic relations of *Fasciola hepatica;* but the writer begs to inform estate-owners, agriculturists, sheep-farmers, stock-masters, and all other parties interested in the welfare of flocks and in the production of cheap and wholesome food, that a true solution of this important economic question, in so far as it relates to the production of healthy meat, can only be obtained by the further prosecution of our experimental researches. In this attitude only can we ultimately hope to achieve a certain knowledge of the means of preventing, if not of entirely eradicating, this fearful disease; and the writer confesses that it seems to him strange that the cost of these necessary experiments should hitherto, in this country at least, have exclusively rested with those who have given much time, aided by such talents as they may possess, to practically scientific inquiries. On independent grounds he has himself, year by year, sought to throw light upon the origin and development of the various internal parasites which either annoy or destroy our valuable animals; and as, in some instances, these experiments have proved eminently instructive, he cannot avoid

expressing regret that the costly nature of these investigations has alone prevented their further prosecution.

Those who desire to know what has been doing in other lands towards the elucidation of this important subject should, in particular, consult the Treatise *De la Reproduction chez les Trématodes endo-parasites, par J. J. Moulinié. Extrait du tome III. des Mémoires de l'Institut Génévois;* and also the excellent helminthological memoir by Dr. H. A. Pagenstecher, of Heidelberg, entitled *Trematodenlarven und Trematoden,* at the close of which latter the author appends a note referring to the above-mentioned work, finally adding, "We are encouraged again to take up our hitherto fruitless searchings among land-snails, and we hope, with M. Moulinié, that the next steps in this direction will clear up the history of the development of *Distoma hepaticum.*" In this desire the writer heartily concurs, regretting only, for the reasons previously stated, that his brother-workers on the Continent should deprive the fair fluke of its proper generic name.

A VISIT TO THE PYTHON IN THE ZOOLOGICAL GARDENS.

BY SHIRLEY HIBBERD.

During the past six weeks the number of visitors to the Zoological Gardens has been considerably augmented by the announcement that the large Python might be seen "incubating her eggs." On the 13th of February I had the pleasure of witnessing the novel spectacle, in the company of a few friends, and the event furnishes a proper opportunity for placing on record a few particulars of the addition thus made to our knowledge of herpetology. Previous to 1849, so we learn from Dr. Sclater's "Guide to the Gardens," "no attempt had been made in this country to exhibit the class of reptiles under conditions which might make it possible to understand anything of their habits." The attempt then made has been eminently successful, and many disputed points in the history of the Reptilia have been settled by the opportunities which the Society's collection has afforded for observation, inquiry into the habits, and specific distinctions of those representatives of the class which have been domesticated in the gardens. There are two structures devoted to them, No. 49, the reptile-house, and No. 50, the python-house. In these warm houses the reptiles are exhibited in a way to ensure perfect safety to visitors and perfect freedom,

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within proper limits, to the inmates of the comfortable, roomy, glass-fronted dens, which are variously furnished with stumps of trees, beds of clean pebbles, drinking and bathing troughs, and other accessories to the well-doing of the formidable pets. Among the principal inhabitants of these houses are, first, *Python molurus*, from India, the subject of this notice*; *P. regius*, *P. reticulata*, *Boa constrictor*; *Chilobothrus inornatus* (the yellow boa); *Crotalus durissus*, the rattlesnake; *Naia haje*, the cobra; *Cenchris piscivorus*, the water viper; *Pelias berus*, the common viper; and a very good collection of snakes, viperines, and batrachians.

Before detailing the results of our visit, a few words on the position of Python molurus in the recognized classification may not be out of place. The method of arranging the Reptilia, adopted respectively by Oppel, De Blainville, Dr. J. E. Gray, Cuvier (*Règne Animal*, 2nd edition), and Bell, are very nearly identical in their leading features; those of Merrem and Fitzinger differ considerably from the systems which have been generally recognized in this country, because they rely chiefly on the characteristics of the integuments; whereas structure and function are comprehended to a more or less extent in the arrangements which have been found most useful. Objections may be made to each of the systems hitherto devised, on the ground that the basis of classification varies at each stage, which is unavoidable in a natural arrangement. The result of this in Dr. J. E. Gray's classification is, that the crocodiles are separated from the turtles by the whole distance of the intermediate orders, the ophidian serpents standing midway between the extremes. Cuvier groups the chelonians and crocodilians side by side, as possessing a heart with a single auricle and limbs; the saurians follow, having a heart with a double auricle, teeth, and limbs; next come the ophidians, comprising all snakes and serpents. At the bottom of the scale are the batrachians. Professor Bell departs from this system only to place the lacertæ below the ophidians, and there is scarcely an exception in any of the systems to the assignment of a position midway between the extreme highest and extreme lowest—to the great class of serpents, which are inferior to the crocodiles, in having either rudimentary limbs or no limbs at all, and superior to the batrachians in the comparatively high functional capacities of the brain and heart.

Cuvier regarded the ophidians as most deserving the name of reptiles of any of the order, for the simple reason that they are without feet. He arranges them in three families—anguis, with scaly skin and three eyelids; true serpents, with scaly skin

* It is labelled Python sebæ, but described by Dr. Sclater as Python molurus.

without a third eyelid; naked serpents, which have no scales. The true serpents, as grouped by Cuvier, comprise those which have no sternum or shoulder-blade. Many of them have, however, rudimentary posterior limbs, of which the boas and pythons are examples. The protrusion of these in the form of anal hooks is usually visible, and they are no doubt of some use to the animal in locomotion, and in that peculiar act of grasping a tree by the tail while lying in wait for prey on the bank of a pool or stream. Professor Owen (*Odontography*) proposes to divide the Ophidia into two groups, in order to separate those which feed on small invertebrate animals from the typical ophidians, which swallow animals of greater diameter than their own. The first have the jaws articulated in a way which admits of no expansion, whereas in the typical ophidians the superior maxillaries are joined by an elastic tissue with the intermaxillary bone, and the articulations of the maxillary rami and the pterygoid bones are also elastic, and a dislocation of the whole framework takes place during the act of deglutition.

The pythons and boas form a very distinct family in the order Ophidia. The hinder limbs are developed under the skin, and terminate in a horny spine on each side of the vent. They are without venom, but are compensated for that by their immense muscular force, by the exertion of which they crush their prey, by the almost painless process of constriction. The pythons at the Zoological Gardens illustrate the external aspects and habits of the family in a most satisfactory manner, and the preparations at the British Museum and College of Surgeons, afford the fullest information of their anatomical structure and typical relationships. There are so few differences between boas and pythons, that those terms have little else than a geographical signification. Those of the old world are usually known as pythons, those of the new world, as boas; though boa is a classic term, and, according to Pliny, was applied by the ancients to certain old-world serpents which were supposed to subsist on the milk of cows. But as Boa is a Brazilian name for a serpent, there is an end of all difficulty as to how the word should have the same meaning both in the East and the West. In the true pythons, the crown of the head is shielded to behind the eyes, the upper and lower labial shields are deeply pitted, and the nostrils are vertical. In the boas the labial shields are smooth, not pitted; the crown is covered with scales, and the nostrils are lateral between two plates. The species which has recently attracted attention on account of its fertility, is Python molurus (Gray), known also as P. Coluber (Linn.), P. Javanicus (Kuhl), P. Tigris (Daudin). It is a native of Hindustan and Java. It is understood to attain to a length of thirty and more feet, but large specimens are becoming rare,

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in consequence of the extension of civilization in the districts where the species is found.

The classical stories of mighty snakes and serpents are all outdone in the event which has been, of late, so attractive in the Zoological Gardens. The sea-serpents which Aristotle describes as upsetting the triremes (l. viii. c. 28), the strangling of the monsters by the young Hercules, Virgil's Laocoon, and the snake that compelled the Romans to retreat from Bagradus, are all, no doubt, truths in disguise; but here is one of the most formidable of the true serpents, and an altogether grand specimen of its race, engaged in a tender maternal office, and exhibiting the utmost solicitude for its charge. Most of the full-grown serpents are shut up in their clean glass dens in solitude, but this motherly python has a male companion, with whom she has lived in peace for the greater part of her term of eleven years' captivity in the Gardens. The male is a small animal—that is, comparatively speaking. His length may be about fifteen feet, and at the time of our visit he was lying coiled up and torpid in his blanket, engaged in the uncomfortable process of changing his skin. The female measures twenty-two feet in length, her weight is about one hundred and twenty-eight pounds. As the proportions are very nearly identical in pythons and boas, it may be interesting here to give the measurements of a specimen in my own collection, the remembrance of which may be useful in assisting visitors to the Gardens to form an estimate of the proportions of the female python during the brief glimpses now obtainable, as she occasionally presents herself to view between the folds of her blanket. This is a specimen of boa-constrictor from tropical America. It measures, in extreme length, twenty feet three inches, the girth at ten feet from the head is seventeen inches, girth just below the head eight inches; width of upper jaw at its junction with the gullet three inches; length of the upper jaw with its four rows of teeth four inches, and the inner plate of the lower maxillary is not so large as the body of a full-grown rat. So far as I could judge by the cursory view obtainable, as the intelligent keeper of the python removed the blanket aside, she is very slightly larger than my own specimen; and I asked the question whether, in the act of feeding, these pythons were ever observed to lubricate the prey with saliva, according to the time-honoured statements in the books. The keeper could declare, from many years' experience in feeding these serpents with rabbits and ducks, that no such lubrication ever takes place.

According to the narratives of Mr. McLeod, Mr. Broderip, and other observers equally reliable, the prey is never heeded unless it exhibits signs of life. The serpent watches it, and strikes it suddenly while it is in motion. The blow is followed

by a rapid coiling of the serpent around the prey, and the constriction upon it breaks every bone, and puts an end to life more suddenly and painlessly than by any method of destruction ever devised by man. In all the carnivorous reptilia, this same habit appears to prevail; they never make an attack while the prey is motionless, but wait till it comes fairly within reach, and prefer to strike when it is in full activity. Even a slow-worm or ringed snake follows the rule; and, though I have often attempted to deceive them when in a domesticated state, by giving artificial motion to a dead frog, the *ruse* never succeeded, and the morsel was refused. My boa could probably gorge a sheep or goat without difficulty, and though the great python at the gardens is usually fed with rabbits and ducks, it could with great complacency make an end of any one of the pretty antelopes that occupy the pens hard by. But the point of interest here is the alleged act of lubrication. The pythons swallow their ducks without even moistening the feathers, but there is a copious flow of saliva within the horrid jaws, and those jaws undergo a distension, which is in effect a dislocation of the dentigerous bones, which return slowly to their original positions when the act of deglutition is completed. The female python when hungry, and especially after a change of skin, will make an end of a dozen rabbits in rapid succession, but her male companion is generally contented with two or three. Though the act of feeding is not to be counted among the elegant exhibitions of a menagerie, and our little British snakes follow the example of their vaster congeners in creating a sense of disgust in the spectator, there is system in it, over and above the immense muscular force displayed. The victim is invariably taken by the head, so that, in its passage down the gullet, the limbs yield to the pressure of the passage; and, as the bones are already crushed by constriction, there is much less tension of the integuments than would be supposed by any mere comparison of the respective dimensions of the gullet and the prey, the dislocation of the jaws being accompanied with a distension of the œsophagus, while the muscular action conveys the prey to the stomach.

Anxious to afford us a good view of the mass of eggs, about which the python has coiled herself immovably, the keeper proceeded to the back of the den, and gently removed the blanket. There she lay in magnificent coils, the rich mottlings of the scaly skin shining as if oiled, and not a crevice perceptible between the folds, so regularly had she disposed herself to maintain the temperature of her eggs. The keeper gently placed his hand against her a few inches below the head, and she turned aside reluctantly, brandishing her forked tongue, and showing a few of the eggs. He then placed the other hand on

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one of the great folds; and by gentle pressure in the opposite direction caused her to uncoil slightly, and display the greater portion of the nest. As she now began to raise her head, and assume a menacing look, her small eyes sparkling with a fire that at least suggested the idea of offended maternity, the blanket was carefully replaced, the door was shut, and Mrs. Python shrunk down again until the blanket lay flat and smooth, as if she nestled yet closer to her unhatched progeny. During the brief view thus obtained, it was evident that there was system in the hatching process. The eggs appeared to be somewhat larger than those of a goose, of the same colour, and the exterior shell, instead of being hard and calcareous, is leathery and elastic. Some of them are green and putrid, but it would be equivalent to a sentence of death to require the keeper to remove them, though their presence may be fatal to the young pythons, should any be hatched. They are connected together by a membrane, and are evidently arranged with care in concentric layers, so that the greater part of them have the full influence of maternal warmth.

The temper of the python when thus slightly disturbed, and her persistency in her work of incubation, severally contradict and confirm the statements of scientific authorities. The Rev. L. Guilding, describing the transportation of a boa to the island of St. Vincent says, "A noble specimen of the boa constrictor was lately conveyed to us by the currents, twisted round the trunk of a large cedar tree, which had been previously washed out of the bank by the floods of some great South American river, while its huge folds hung on the branches, as it waited for its prey. The monster was fortunately destroyed, after killing a few sheep, and his skeleton now hangs before me in my study, putting me in mind how much reason I might have had to fear in my future rambles through the forests of St. Vincent, *had this formidable reptile been a pregnant female*, escaped to a safe retreat." The pythoness is evidently in no temper to be disturbed while waiting in instinctive expectation for a happy issue to her tedious incubation, and very few who have witnessed this spectacle will agree with Mr. Waterton that "the pythoness herself would comprehend nothing of what was going on"!

Previous to the extrusion of the eggs, this python exhibited evidence of uneasiness. She had a plethoric look, and it began to be questioned whether she might not have swallowed a blanket. Fearing the loss of so valuable a creature, it was determined that, on Monday, the 13th of January, an emetic should be administered, when lo! on that very morning the keeper found his pet engaged in incubation, the eggs having been laid on the night of Sunday, Jan. 12th. Once she left

them for a few moments, and then it was estimated there were upwards of a hundred, but the precise number will probably never be known.

On this matter of incubation authorities differ. The author of the *Treatise on Reptiles* in the *Encyclopædia Britannica* says, "No reptile is known to hatch its eggs." In the *Gardener's Chronicle* of February 22, Mr. Waterton says, "The body of a snake is hard and cold, and scaly; qualities quite useless in hatching eggs, which require warmth and softness, and pliability when birds sit on them; and the heat of the sun and dryness, when the atmosphere acts the part of a parent." On the other hand, the *English Cyclopædia* says, "They (the pythons) are distinguished by placing their eggs in a group, and covering them with their bodies. This statement, which was made by Mr. Bennett, and afterwards confirmed by M. Lamare-Picquot, has been doubted; but its truthfulness has been confirmed by the proceedings of a python in the Garden of Plants at Paris." (Vol. i. Boidæ, c. 540.)

On the 13th of February last, the pythoness had fasted for twenty-five weeks, and then disdained food, and thrust from her the rabbits which were allowed to skip about her cage unsuspectingly as a temptation. She drinks freely; and there is a large tank close at hand, so that she can obtain water without quitting her eggs. The temperature of her den averages 70°, and the temperature of the eggs may be estimated at 80°. As numerous broods of serpents have been artificially hatched at the Gardens, the temperature favourable to the process is a matter of importance. The time usually occupied is sixty days, in a temperature of 80°. It is anticipated that the incubation of the python will be at an end, for better or worse, on the 20th of this month, which will be seventy days from the deposition of the eggs. Opposite the den of the pythoness is a viper, which was hatched from an egg in the Gardens in 1860, and at the rear of the den is a cage full of little viperines (*Tripodonothus viperinus*), which I had the pleasure of playing with, which were hatched artificially; they now average from ten inches to a foot in length, and are lively, interesting creatures that change their garments frequently, and eat a prodigious number of mice and frogs.

The age of the pythoness is not known. She is supposed to be about thirty years old, and if we may assume that her magnitude has not increased at the rate it would have done had she been free instead of caged during the past eleven years, the measurement in feet will afford a near approximation to the number of years of the existence of such a creature. She may bring out a few little pythons from her mound of eggs, and a new attraction will thereby be offered to the sight-

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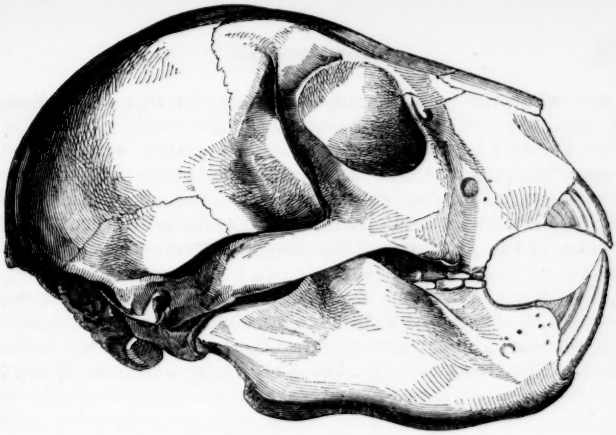
seers who will haunt London during the coming summer. In the year 1841 a similar circumstance took place with a pair of pythons in the menagerie of the Jardin des Plantes at Paris. The phenomena of the reproduction of the young pythons in this case were accurately watched by Professor Valenciennes, and the results of his observations published in the *Comptes Rendus* of the Academy of Sciences of Paris. The number of eggs in this case was only fifteen, and the mother sat bravely on, until, at the length of two months, eight young ones were produced. Professor Valenciennes has attempted to show, by careful thermometrical experiments, that this female python, during her incubation, developed heat to the amount of ten or twelve degrees (centigrade) above the temperature of the surrounding objects. But it has been considered by other authorities on the subject, that there is some doubt whether this increase of heat was really caused by the incubative action, and there is still much uncertainty upon this point. Experiments made at the Regent's Park Zoological Gardens go to show, according to the report of Dr. P. L. Sclater, "that the heat of the incubating female python is not greater than the heat of a non-incubating boa in an adjoining compartment."

THE AYE-AYE.

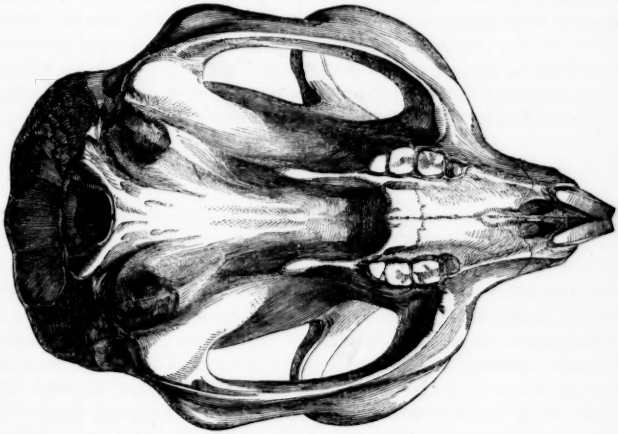
BY W. B. TEGETMEIER.

THE Aye-aye of Madagascar, the *Chiromys Madagascariensis* of Cuvier, is one of the most anomalous of living mammalia. In consequence of the exclusion of Europeans by the tyranny of the late queen, but little information has latterly reached Europe respecting the productions of that island, so that one of our best known naturalists has stated, in a book published within a few weeks, that "not a specimen of the aye-aye has, as I believe, been seen since Sonnerat's day, so that if not actually obliterated, the species must be on the verge of extinction." Fortunately, this conjecture is not borne out by the facts of the case; the recent throwing open of Madagascar to Europeans has made known that the natives regard the animal with interest, and Dr. Sandwith has availed himself of his opportunities, as Colonial Secretary at the Mauritius, to obtain these animals in a living state, and to study their actions and habits.

A specimen, most carefully preserved in spirits, has also been recently forwarded to Professor Owen, who has studied its structural peculiarities, so that at the present time we are in possession of much fuller details regarding this extraordinary quadruped than heretofore, and are enabled to arrive at



SKULL OF AYE-AYE.



BASE OF SKULL OF AYE-AYE.

LOWER JAW OF AYE-AYE.

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a somewhat more satisfactory conclusion as to whether it is to be regarded as a gnawing animal with the grasping hands of a monkey, or a monkey with the rat-like teeth of a rodent. On consideration of the most important peculiarities in its structure, we cannot fail to observe their extraordinary adaptation to the habits, food, and mode of life of the animal, as recently made known by the peculiarly interesting observations of Dr. Sandwith.

The aye-aye is about the size of a small cat. The head is peculiar, the eyes being directed forwards, and not laterally as in rodents. The ears are of large size, and also directed to the front. The trunk is large, the chest being well developed; the

FOREHAND OF AYE-AYE.

body is clothed abundantly with hair, and terminates in a long bushy tail, which does not possess any power of grasping. The great peculiarity of the outward form of the animal is in the fore limbs, which somewhat resemble those of a lemur. The fore-hand, like that of man and the quadrumana generally, is capable of being turned either into the prone or supine position. The first digit is readily opposable to the others, and so constitutes a true thumb. The index finger, as shown in our engraving of the fore-hand, is very short; the middle finger is long, and so singularly attenuated as to appear withered or deformed, whereas the other fingers are of the ordinary thickness. The palm is naked, and the whole hand looks not unlike the miniature of a deformed and paralyzed human limb. The

hinder hand has a powerful grasping thumb, and resembles closely that of the lemur, and other nocturnal quadrumanous animals.

The teeth of this animal, however, offer a remarkable departure from the monkey type. The fore teeth, as shown in the views of the skull, are truly those of a rodent or gnawing animal. having sharp, cutting edges, and are furnished with a layer of enamel on the front surface, which, like the steel facing of an iron chisel, keeps them constantly keen and in cutting order. Like the teeth of a rodent, they are continually growing during the life of the owner. They differ, however, somewhat from the incisors of our common gnawing animals, in being very narrow in proportion to their great depth from front to back.

The grinding teeth are much more vertical in their position than those of rodents, and instead of being formed of alternate transverse vertical ridges of bone and enamel are capped with smooth crowns of enamel, as in man and the quadrumana generally; their number is unequal, being, as shown in our engravings, four in the upper, and three in the lower jaw. The skull compared with that of the squirrel, is larger, the brain-case being well developed, and the brain itself resembles that of a lemur, and not that of a rodent. This wonderful combination of the structure of two groups of animals, so widely removed as are the quadrumana and the rodentia, has hitherto proved exceedingly puzzling, especially to those naturalists who imagine that all animals should be constituted with reference to some given type. To those, however, who are intent upon tracing the intimate relation that exists between structural peculiarities and habits, the aye-aye is one of the most interesting of all animals, but until the exact nature of its habits were made known by the communication of Dr. Sandwith, this relation could not be accurately traced.

The aye-aye is a nocturnal animal, sleeping during the day and becoming active at night, as might be inferred from its large circular eyes, wide iris, and great expanse of pupil. Its food, as indicated by its simple molars, consists in great part of fruits and soft vegetable substances, such as dates; that it is a climber is evidenced by the grasping character of its extremities. It was not until Dr. Sandwith accidentally placed some branches for the living animal to climb, that the true co-relation of its organs to its habits was noticed. These branches had been perforated by some wood-boring larvæ. On being placed in the cage of the aye-aye, the animal was observed to direct the large expansive ears towards them; when its acute sense of hearing gave evidence of the working of some concealed insect in a larval state. The long attenuated finger, that even Buffon himself could now no longer regard as a defor-

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mity, was employed as a probe; it failed to reach the intended prey, so that the slender hooked claw, with which it is armed, was for a time useless, but the powerful gnawing teeth of the animal were instantly put into requisition; sufficient of the wood was rapidly bitten away to enable the probe-like middle-finger to be inserted with success, and the slender claw transfixed and drew forth a large luscious larva, which was devoured with the greatest relish.

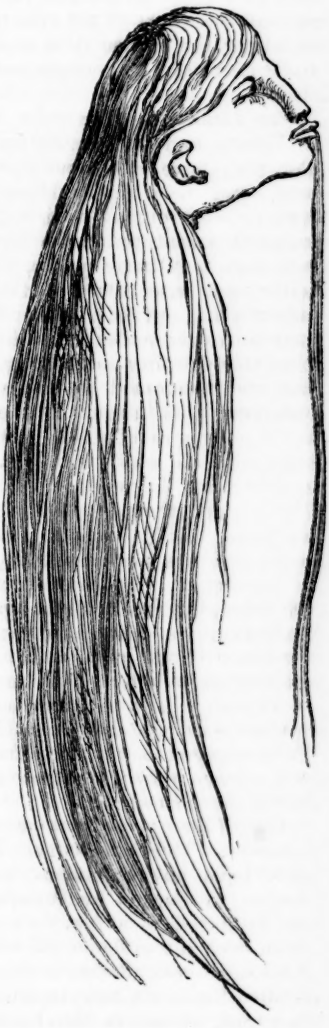
The peculiar configuration of the aye-aye is no longer a mystery; its grasping hinder hands, leaving the fore limbs free, its long attenuated probe-like finger, with its slender hook-like claw; its enlarged ears, its gnawing teeth, are all evidently adapted to the habits, instincts, and food of the animal, and although they may not enable closet naturalists to locate it with unerring certainty in this or that artificial group; they, nevertheless, prove what is of much more importance to be determined, that there is a co-relation of structure with external circumstances, which proves, as far as such evidence can prove, that the organs of the animals are formed with special and direct reference to the objects upon which they are to be exercised.

THE IDOL HEAD OF THE JIVAROS.

BY WM. BOLLAERT, F.R.G.S.

On the eastern side of the Republic of Ecuador, formerly known as Quito, live a tribe of Indians called Jívaros, a strange, wild people, dwelling in the midst of a most beautiful mountainous country rich with tropical vegetation, and dense forests, and including in its wild grandeur the by no means inconsiderable volcano of Macas. There, may be found, among other valuable vegetable productions, the handsome mahogany, sandal, and ebony trees, the cinchonas, india-rubber, copal, storax, indigo, guayusa, canelo, etc., most of them well known to civilized life, and all of them deserving to be so for their useful properties and capacities. The laurelo or wax palm is very abundant, the wax being obtained by merely scraping it off the bark. Cotton, of a long fibre, strong, and of a fine quality, grows there indigenously; no limits could be put to its cultivation, and the Amazon affords an easy shipment to Europe. Coffee and cacoa grow freely. The guayusa, a plant which the Indians cultivate near their huts, might probably compete with tea from China in the English market, as it has a similar aromatic flavour without bitterness. Canelo is a species of cinnamon; the ishpingo is the calyx of its flower. It is equal

in flavour to the best East India cinnamon, and 3000 to 4000 lbs. of it are annually gathered. A wholesome and nourishing drink is made from the *Jatropha manihot*, and this valuable root is of almost universal use as food, and for many other purposes throughout Ecuador, New Granada, and Peru. The Torquilla palm is most abundant, and yields the beautiful straw used in making the Panama hats.



In addition to all this vegetable productiveness and wealth, this favoured district is rich in gold, and may boast of having the famous auriferous mountain of Llanganate within its boundaries. The natives are not slow in turning this to their own account, and quickly collect for the traders an ample supply of the precious metal to exchange for their much coveted goods. The fertility of the soil is, in a great measure, to be attributed to its plentiful irrigation, not only by the smaller rivers, Chinchipe, Pastasa, and Marañon, but likewise by the mighty Amazon, of which they are tributaries; and it is in the forests among these rivers that the Jívaro Indians now make their homes. They are an ancient and warlike people, and their history is given by Velasco, the historian of Quito, together with an account of their conspiracy against the Spaniards in 1599, an outbreak which procured for them the title of Arau-

canos of the North. At that period they made the governor of Macas prisoner, and killed him by pouring molten gold down his throat; afterwards they destroyed the Spanish settlements in their part of the country in one day, killing the men, but taking the women into captivity. In modern times many expeditions have been organized to punish them, but all have failed.

The Jívaros are a warlike, brave, and astute people; they love liberty, and can tolerate no yoke. Their bodies are muscular, they have small and very animated black eyes, aquiline noses, and thin lips. Many have beards and fair complexions, most probably arising from the numbers of Spanish women they captured in the insurrection of 1599. They have fixed homes, cultivate yucas, maize, beans, and plantains, and their women wear cotton cloth. They live in well-built huts made of wood, and sleep in fixed bed-places instead of hammocks. Their lances are made of the Chonta palm, the head being triangular, thirty to fifty inches long, and ten to fifteen inches broad. They are accustomed to take a strong emetic every morning, consisting of an infusion of the guayusa, or tea plant, for the sake of getting rid of all undigested food, and being ready for the chase with an empty stomach. Their hair hangs over their shoulders, and they wear a helmet of bright feathers. Velasco, in 1789, divided them into three branches; Villavicencio, in our own times, divides them into ten, all speaking the same language, which is sonorous, clear, and harmonious, easy to learn, and energetic. Their branch tribes are constantly at war with each other, but readily unite against a common enemy. Their dissensions are frequently caused by their good living; the abundance of fish and game makes them saucy to each other, which often leads to serious quarrels.

At each village they have a drum called *Tunduli*, to call the warriors to arms, and the signal is repeated from village to village. When engaged in war, their faces and bodies are painted; but during peace they wear breeches down to their knees, and a shirt without sleeves.

One of their prominent customs is to deify the heads of their prisoners. This fact has been known for some time, but only lately have any specimens been obtained. The first was brought to Europe by Professor Cassola in June, 1861, and was exhibited to a few persons in London. This had been stolen from a temple on the river Pastasa. At the latter end of the same year another specimen fell into the hands of Don R. de Silva Ferro, Chilian consul in London, with an explanatory document, which has been translated by Mr. Bollaert, and communicated to the Ethnological Society, together with some account of the Jívaros themselves.

The Idol Head from which our sketch is taken, was obtained through a baptized Indian, who persuaded a Jívaro, notorious for ill luck, that this was occasioned by the imprisonment of the idol, who was desirous to travel. The Jívaro handed it over for this object, when it was taken to the governor of Macas, who sent suitable presents to the Indian in return for his interesting gift.

These curious trophies are thus prepared: after a war the heads of the victims are cut off, the skull and its contents removed, and a heated stone (it is said) is introduced into the hollow of the skin; desiccation goes on, and it is reduced to about one-fourth, retaining some appearance of the features.

A feast ensues, when the victor abuses the head roundly, to which the head is made to reply in similar terms—the Indian priest being the spokesman for the head, or *chancha* (an Indian name for a sow), and he concludes his part thus: "Coward! when I was in life, thou didst not dare to insult me thus; thou didst tremble at the sound of my name. Coward! some brother of mine will revenge me." The victor at this raises his lance, strikes, and wounds the face of his enemy, after which he sews the mouth up, dooming the idol to perpetual silence, excepting as as an oracle; questions being put to it when the inquirer is under the spell of a narcotic.

When the Jívaro is pressed by the enemy, and has not time to cut off the head of a victim, the ceremony is performed on the head of a sow, which is adored as a real Idol Head. Should the fruits of the earth not be in abundance, the women hold a feast of supplication to the head, and if their request is not granted, the hair is shaved off, and it is thrown into the woods.

A double string is attached to the top of the head, so that it may be worn round the neck. The lips are sewn together, and a number of strings hang from them, the use of which is not apparent.

MEDIÆVAL ENGLAND.*

Among the aids to the philosophical study of history, a high place must be given to the labours of the modern archæologist, who has collected and arranged an innumerable array of facts, by the help of which it is possible to reconstruct the society of

* *A History of Domestic Manners and Sentiments in England during the Middle Ages*, by Thomas Wright, Esq., M.A., F.S.A., Corresponding Member of the Imperial Institute of France, etc., with Illustrations from the Illuminations in contemporary Manuscripts and other sources, drawn and engraved by F. W. Fairholt, Esq., F.S.A. Chapman and Hall, 1862.

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the past. It is no longer fancied that to learn by rote a few score of names and dates, to get up "tables of kings," and long lists of battles, is to become a historian. In looking back to any particular period, we want to know something more than the external facts of public and political transactions. We desire to gain an insight into the conditions of the people, the relations in which the various classes of society stood towards each other, and to understand the nature of the impulses by which retrogression was compelled, or progress was achieved. The ideal of social development is the substitution of enlightened opinion for brute force, the enlargement of the total quantity of the means of well being, and their more equitable diffusion, so as to realize Bentham's grand desideratum of the "greatest happiness of the greatest number." Keeping this in view, we are especially interested in those movements by which mediæval ideas and institutions were gradually replaced by modern arrangements, destined in their turn to give way before that increase of intelligence which promises to be the great characteristic of the next epoch in the civilization of man.

An enlightened study of history is alike fatal to a superstitious reverence, or a self-sufficient contempt of the past. We discover no "good old times" that we would exchange for our own, and in the sense in which Tennyson exclaims—

> "Through the shadow of the globe we sweep into the younger day;
> Better fifty years of Europe than a cycle of Cathay,"

we value a year of the present more than a generation of a barbarous age. And if such a comparison tends to puff us up with pride, the very study which suggests it, supplies the corrective of which our vanity has need. We select, for example, a period in our own history many centuries ago; we see the action of the upward struggle which was then going on, and we find that, notwithstanding our inheritance of the victories which our forefathers won, the work which remains to be accomplished is far larger than that which has already been achieved, and we are made to feel that, although our days may be hereafter "good old times" to our posterity, on account of the serviceable materials we shall leave behind us, they will likewise be "bad old times" when a wiser generation looks back upon the ignorance, crime, pauperism, and suffering by which our condition is so sadly marred.

A work like Mr. Wright's *History of Domestic Manners and Sentiments in England during the Middle Ages*, furnishes a store of delightful reading bearing upon the preceding remarks. Aided by his laborious, but gracefully employed learning, and assisted by the hundreds of curious illustrations copied from authentic sources by Mr. Fairholt's pencil, we can make a morn-

ing call upon the Anglo-Saxons, dine with the Anglo-Normans, or pay a familiar visit to the early Englishman, when the conflicting races were fused together, and a single national appellation became the grand name of all. We find the Saxon, so far as the upper class was concerned, in a higher condition than has often been supposed, and after Roman influence had been felt, his mode of life was not wanting in the elegance that is compatible with a rough iron age. Although stone was occasionally employed, the chief material for the construction of habitations was wood, and the carpenter was the builder in those simple days. The principal apartment was the hall, or public living room for the family and their guests. Internally it was covered, by those who could afford the luxury, with "wall clothing," or hangings, either of plain cloth, or richly ornamented with embroidered patterns, or pictures of historic scenes. So early as the seventh century, Mr. Wright tells us, that Aldhelm observed that if the tapestries were of "one colour, uniform, they would not seem beautiful to eye." These hangings, together with arms, armour, and trophies of the chase and war, constitute the most noticeable decorations of the abode; but we find ornamental tiles covering the roof, and variegated or tesselated pavements not unknown for the floor. The vessels of domestic use were not without a fair share of beauty and constructive skill. The bowls with double handles were of graceful form, and buckets, probably used to hold ale or mead, were decorated with bronze handles and hoops, exhibiting considerable knowledge of design. Very characteristic also were the drinking vessels, especially the "tumblers," rounded or trumpet-shaped glasses which would not stand, and which the topers of both sexes emptied at a draught. One of them, sketched by Mr. Fairholt, is elegantly fluted, while another exhibits a "twisted" pattern often mentioned by Beowulf, and evidently highly esteemed by the fashionables of his day. Separated from the hall were the "bowers," or private sleeping rooms, in which very little luxury was displayed. The bed was a sack of straw, the bed-clothes of a primitive character, and night-gowns (as was the case for many centuries) consisted merely of the natural covering which Nature provided when she benevolently furnished our progenitors with a skin. The table in the living room, or hall, was, for the most part, literally a "board," which tressels supported when its services were required for the rough but hospitable meal. Very harsh were the distinctions of class, but, nevertheless, certain elements of equality prevailed. All halls were open, and any stranger, however lowly his condition, was at liberty to enter, and take his place even at the "board" of a noble or a king. The dinner must have been a very clumsy and dirty affair. In an old picture, given by Mr. Wright,

we see a table covered by an ornamental cloth, but destitute of plates, and although some rather good-looking vessels are in use, the meats are presented by kneeling domestics upon the spits with which they were prepared, and the guests cut off the tit-bits with clumsy knives. The treatment of servants, even by ladies, was very brutal; fetters and flagellations being freely employed. Mr. Wright thinks it probable that the early babies of our country were swaddled, but whatever may have been their treatment in this respect, maternal tenderness was not sufficient to prevent the common occurrence of gross negligence, and Archbishop Theodore, who lived in the latter half of the seventh century, found it necessary to enjoin a special penance to mothers who left their children on the hearth, exposed to the unfortunate influence of an over-boiling pot. Nor could the matrimonial system be considered quite perfect, when a law of Ethelred provided that any gentleman who was guilty of over fondness for his neighbour's wife should buy him another as compensation for the wrong.

At a very much later period it is surprising to find how deficient our ancestors were in what we should call the necessaries of life. Thus the *Ménagier de Paris,* a work written about the year 1393, informs us, that the servants who had charge of candles used to accompany those valuable articles to the bed-rooms, and hold them in their hands until the would-be sleepers had undressed and gone to rest. Similar adventures repeatedly occurred to Mr. Olmsted, in his recent travels through the semi-barbarous Slave States of America, and, indeed, as we read his *Cotton Kingdom,* the details of brutality and discomfort often remind us of the dark ages in European lands. The coarseness of those times has been thought by superficial observers to have been consistent with moral innocence. Mr. Wright, estimating them more profoundly, asserts that the "whole tenor of contemporary literature and anecdote will leave no doubt that mediæval society was profoundly immoral and licentious." Of course it was. Nothing else was possible, unless in exceptional cases, when the rights of individuals were very imperfectly recognized, when the mind of the people had no rational employment, when ignorance was universal, and gross superstition exercised an almost unbroken sway.

The position of woman is a sure index to the condition of society, and some old books which our author cites are very instructive on this head. Thus we find a social moralist, the Chevalier de la Tour-Landry, instructing his daughters in matrimonial obedience, by telling them what happened to a lady who ventured to contradict her lord and master, and was thereupon knocked down and kicked, so as to break her nose, and thus disfigure her for life—a punishment which the chivalrous

narrator thought justly warranted by the offence. Another reformer of domestic manners, Robert de Blois, who furnished young ladies with a code of instruction in verse, entitled the *Chastisement des Dames*, does not make us in love with the ways of feudalism in the fourteenth century. Many of his directions point to practices of gross indecency, and the believers in the so-called "ages of faith," which preceded the Reformation, may be astonished to find it was necessary to recommend the daughters of noble families not to get drunk, and not to use the table-cloth for a pocket handkerchief when they went out to dine!

It is customary to talk of the refined cookery introduced by the Normans, but when the luxury of feasting was at its height, we do not discover any rational principles of culinary art. The dinners were elaborate and costly, consisting of many courses, prepared with great trouble and expense, and yet scarcely a dish would be tolerated by the palate of modern times. In the fourteenth and fifteenth centuries there seems to have been a rage for highly-flavoured compositions, in which the ingredients were mingled with little regard to what we should consider their natural affinities. Perhaps equally disagreeable combinations might be selected from the records of Roman feasts; and there is scarcely anything, however nauseous, to which habit and fashion will not reconcile the accommodating stomach of man. Here is a specimen of a delicacy in the days of Richard II.; it is called a *farsed browet*, or *browet farsyn*:

"Take almonds, and pound them, and mix them with beef broth, so as to make it thick, and put it into a pot, with cloves, maces, and figs and currants, and minced ginger, and let this seethe: take bread, and steep it in sweet wine, and 'draw it up,' and put it to the almonds with ginger: then take conyngs (*rabbits*) or rabettes (*young rabbits*), or squirrels, and first parboil, and then fry them, and partridges parboiled: fry them whole for a lord, but otherwise chop them into gobbets; and when they are almost fried, cast them into a pot, and let them boil altogether, and colour with sandal-wood and saffron; then add vinegar and powdered cinnamon, strained with wine, and give it a boil; then take it from the fire, and see that the potage is thin, and throw in a good quantity of powdered ginger."

During the thirteenth and fourteenth centuries a desire for education exercised a beneficial effect, and Mr. Wright artributes this movement to the rise of an industrial class. It was, as he tells us, the merchants in the towns who made the first step in advance, and founded the most important local schools. We could have wished he had devoted more space to tracing the growth of the intellectual element in English society, and ex-

hibited the enormous difficulties it had to encounter, and the causes of its very slow success.

Even in the fifteenth century, notwithstanding the augmented wealth of the middle class, and the importance assigned to a more private apartment than the hall, the conveniences were so few as to indicate that very little talent had been exerted in contriving the arrangements of domestic life. Thus the "parlour" was thought well furnished if it had a hanging of worsted, a cupboard of ash board, a table and a pair of tressels, "a branch of latten with four lights;" a pair of andirons, a pair of tongs, one form, and one chair. Looked at as a social institution, the "parlour" was a grand invention. Life then acquired the possibility of privacy, with some share of comfort, and the morals of the ladies were improved by having a convenient room to receive their visitors, without taking them, whether male or female, to the retirement of the bedchamber or "bower." Domestic discipline was, however, still founded upon "laws" analogous to those of which Canning represented Mrs. Brownrigg to have dreamt, and the wife of Sir William Paston, in 1454, probably did not depart far from the general custom, in beating one of her daughters one or twice a week, and sometimes twice a day. As vice and brutality were common qualities, demure propriety of outward demeanour was rigorously enforced while the sons and daughters were under the parental eye. We have a sketch of a little party at which all present sit with their hands crossed before them in solemn state. There were, however, redeeming features; music was commonly cultivated, and women began to distinguish themselves in literary acquirements, or through the practise of the painter's art. In the sixteenth century, progress became more rapid, and with the emancipation of intellect from mediæval bondage, we notice a wider departure from the ancient ways.

The growth of a nation is no more an accident or a combination of accidents, than the growth of a flower from its seed. We are to this day what our forefathers made us, modified by our own energies, and the circumstances of our time; but as society moves onward, the scope for individual exertion becomes enlarged. It may be more difficult for a single great man to tower above the rest, but whoever can think a good thought or suggest a valuable course of action has the many to listen to him, instead of the few. Society is not an aggregation of independent units, but a vital whole, so bound together that its highest advances, are possible only when the interests of all are cared for and sustained. Our life is richer than that of the past, because it is compounded of more varied elements, as both our exertions and our speculations take a more extended range. It is richer also through the improved

condition of social relations, and the larger proportion of persons who share with us the advantages of civilization, and contribute their mental and moral forces to the common stock. We love to trace the past through the pages of a delightful work like Mr. Wright's *Domestic Manners of the English*, which will commend itself to all readers, but in proportion as his admirable descriptions bring the old times home to us, not like the figures on a faded tapestry, but with the vividness of actuality, we are glad that we are workers in the present, and, as we trust, servants of the future, by sowing seed that may hereafter bear serviceable fruit.

DOUBLE STARS,

BY THE REV. T. W. WEBB, F.R.A.S.

If on some transparent night, when the moon is absent, and "the firmament glows with living sapphires," we take our stand in the open air and gaze around us and above us, as silent worshippers in the great Temple of Creation, our first impression will probably be, as it was with Abraham in the plain of Mamre, that of the presence of multitudes innumerable. A more concentrated attention to any circumscribed portion of the sky will reduce our estimate, and we shall find that the number of stars which we can actually reckon will be but moderate, or even few in proportion; but a general view, in restoring liberty to our gaze, will bring back our first impression in all its strength. When the eye is relieved from the immediate effort of counting, and especially when we can give our attention to those oblique pencils, to which, as astronomers know, the retina is peculiarly sensitive, we shall detect unnumbered glimpses and sparklings over the whole ground of the firmament. If now we take some common telescope, even of the smallest dimensions, and point it to those twinkling regions, we shall find our surmise converted into certainty by the distinct appearance of stars in many places where we had only suspected them; if we lay aside our instrument for larger ones, we shall perceive that every successive increase of aperture brings fresh discoveries into view, till at length, in using the great reflectors and achromatics of the present day, we find that the faint points of light, revealed in their space-penetrating fields could literally be numbered by millions.

Amid such inconceivable profusion, it must of course be a frequent occurrence that two stars are found in very close proximity to each other, constituting the objects so well known

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as a double, or, in some cases, triple, quadruple, or multiple star. If, however, their mutual distance is sufficient to admit of their being separately distinguished by the naked eye, they are seldom classed under these titles, which are, generally speaking, reserved for those too close, as well as in many cases too minute to be seen without a telescope. Of such it has been computed that there may be about 6000 in the heavens (including of course both hemispheres), and as many of them are especially interesting objects of telescopic research, it is intended in the present paper, and others which will form its continuation, to give some plain directions which may enable amateurs to find them readily, and view them to advantage.

But in the first place it may be asked, what peculiar interest do stars acquire from being thus brought into juxtaposition? In many cases it may be answered, that the mere comparison of magnitude, or contrast of colour, thus brought out, is both singular and beautiful, and will well repay the slight trouble of the search. But others possess a higher claim upon our attention. In many instances they are not merely supposed, but ascertained to be systems of connecting suns, bound together and revolving round each other by the same combined action of gravitating and propulsive force which governs the motions of our solar system, and is thus proved to pervade the nearer regions, and must by analogy be supposed co-extensive with the whole domain of the starry universe. Such pairs of stars are called *binary*, to distinguish them from those whose duplicity is only optical or apparent; the mere accidental consequence of their lying behind each other in a line passing nearly through the observer's eye. This distinction cannot be demonstrated by a single observation, however accurate, but may be effected in two different ways, by examinations repeated after sufficient intervals of time. In many instances, as experience will readily show, the very aspect of a pair is enough to point out the probability of its physical relation. The components are frequently so curiously alike in physiognomy, if we may so apply the term, that their family connexion is all but self-evident; and the chances are exceedingly small that in such a case one object should be found almost exactly in a line with another, whose difference in size is so precisely balanced by a corresponding difference in distance, as to produce the effect of equality. Still this, though a very high probability, does not amount to actual demonstration, which can only be obtained, as we have said, in one of two ways. Either we may observe such a change from time to time in the relative position of the two stars, as actually to exhibit their revolution to the eye; or we may find them, after the lapse of years, though sensibly unmoved with respect to each other, get both gradually displaced through

equal distances from their former position, and travelling in company on an unknown and mysterious way through the vast expanse of creation. It is well-known that the term "fixed" is most incorrectly applied to the stars, a great proportion of which are found to change their places in the sky year after year, with a slow but steady progress, the combined result, it is believed, of their own movement, and a similar motion on the part of our sun. How this "proper motion," as it is called, can affect a pair of stars equally, and thus show their comparative nearness to each other, while yet they exhibit no appreciable motion of revolution round each other, is wholly unknown, though it may perhaps point to an extraordinary deficiency in mass, as compared with magnitude or luminosity; but who can wonder at our ignorance of the nature of those distant suns when we know so little of the constitution of our own? It is of course possible that a progressive motion in the sun may cause the apparent movement of a double star in the opposite direction; but it is obvious that such an illusory displacement would betray its cause by the inequality of its amount in the two stars, unless they were nearly at the same distance from the eye, on which supposition we are brought round to the same point again, by this proof that they were actually adjacent, a real *pair*. It is then by the one or the other of the these two ways—by displacement relatively to each other, in such a manner as to show revolution round a common centre of gravity, or by displacement relatively to the ground of the heavens, and common to both individuals, that a very large proportion of double stars are ascertained to be mutually dependent systems.

The study of these interesting objects has been advancing with rapid steps. Only about four double stars had been noticed, or at least recorded, when the elder Herschel began to turn his powerful reflectors upon the heavens. He soon perceived the importance of his research, and in 1782 published the first of a series of catalogues containing in all about 500 stars; but it was not till the beginning of the present century that, in seeking for the parallax of the stars in order to determine their distance, he obtained unquestionable evidence of the mutual relation of some of these pairs. His son, and other observers, followed in the same track, and at length W. Struve, then at Dorpat, but subsequently Director of the Imperial Observatory at Poulkova, near St. Petersburg, produced a catalogue of 2787 double stars, lying between the North Pole and 15° of south Declinations, which has since been universally regarded as the great authority for that portion of the sky. According to him there were, in 1837, fifty-eight systems within his limits, known to be undoubtedly binary, thirty-nine

probably so, and sixty-six suspected. In 1849, Mädler, his successor at Dorpat, considered that 650 pairs throughout the heavens were certainly of binary character; and the subsequent period, if, in some instances, it may have thrown doubt upon hasty inferences, has on the whole added materially to the number. The chief increase, however, has not been due to the discovery of fresh objects, for the superiority of the Dorpat telescope, which has 9·43 inches of aperture, and the unwearied zeal of Struve, who carefully examined with it in two years about 120,000 stars, left comparatively little to be done in the northern hemisphere; it is the interval of time, which by enabling the slower movements to be recognized and measured, has developed a new character of connexion in many pairs previously known.

The amateur who is impressed with the extreme sublimity and beauty of these distant exhibitions of the Creator's glory, will not be satisfied with a cursory glance, but will like to see, and see carefully, all that his instrument can show him. It will be, therefore, well to specify the following as the points of interest in double stars.

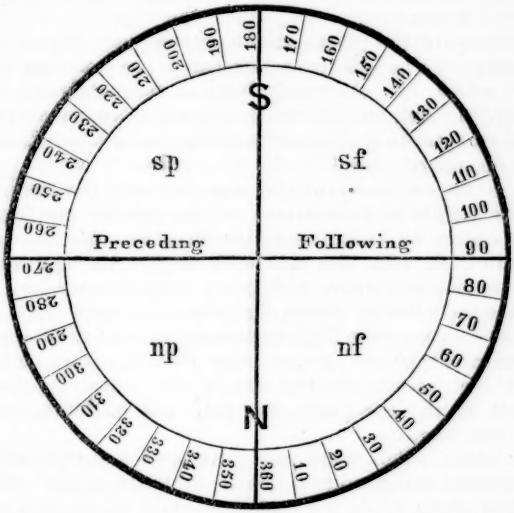
1. *Magnitude.*—It is to be regretted that on this head there is much that is very arbitrary and uncertain; the magnitudes of stars as given by different authorities varying sometimes to a surprising degree. Sir J. Herschel, Argelander, and others, have indeed done much in the very difficult inquiries of stellar photometry, but the results are either not fully satisfactory, or have met with a very limited application. In the present series of papers the data of Admiral Smyth's most accurate and valuable *Bedford Catalogue* will be adopted as the standard, in this as well as all other respects, with occasional additions from other quarters.

2. *Distance.*—This is one of the most important elements of observation, and gives more especially its character to the aspect of a pair of stars. It is always measured from centre to centre, and expressed in seconds and decimals of arc (on space). We often find the decimals carried to three places in these measures, but it is of course not to be supposed that instruments exist capable of marking, or eyes of discriminating, such subdivisions; they merely express a mean deduced from many observations. In Smyth's measures such refinements are not employed. The Dorpat Catalogue terminates at 32″ as its exterior limit, but from a calculation of chances it appears that there is a possibility of mutual relation even as far as 15′; that is to say, between stars, double, even to the naked eye.

3. *Position* of the components with respect to each other.—This deserves the more attention, as being one of the elements which would vary on the supposition of orbital motion, and by

which it would be most easily recognised. It is always determined by measuring the angle between two lines, one, the parallel of declination passing through the larger star, or in other words, its apparent course through the field of the telescope; the other, a line drawn from the larger to the smaller star. Astronomers estimate the positions of all objects near one another in this way, and amateurs, unprovided with the convenient apparatus, called a *position micrometer*, will do well to master thoroughly the accompanying diagram.

It represents the field of an astronomical eye-piece, in which objects being inverted, the N., where the measures commence, will be found at the bottom, the S. at the top: the line joining



them is a portion of a meridian; the one at right angles to it is a parallel of declination, along which (or parallel to which) all objects move across the field from right to left, or from the word "Following" towards "Preceding." The initials *n. p*, *n. f*, *s. p*, and *s. f*, which are constantly used in astronomical works, stand for *north preceding*, *north following*, *south preceding*, and *south following*, and characterize the quadrants in which they are respectively placed, so as to show at once, and in a most convenient way, the general bearings of objects, where accuracy of measurement is not required. In describing a double star, the larger of the two, if differing in size, is supposed to be placed in the centre of the field, and the position of the lesser one, which, if very small, is often called a *comes*,

or attendant, is given, if roughly, by the quadrant in which it stands; if accurately, by the degrees included in the angle already referred to, which is called its *angle of position.*

In estimating angles of position, for the purpose of tracing orbital motion, or knowing in what direction to look for very minute attendants, the inexperienced observer may at first be much puzzled, and frequently misled, by the varying situation of the N. point, or zero of the diagram, according to the quarter of the sky in which the object is situated at the time. From the amount of elevation of the pole in our latitudes, the transits of stars through the field may be performed at angles of every degree of inclination in one part or other of the sky, and the line which stands horizontally in our diagram will be sensibly horizontal in the heavens only when the object is in, or near, the meridian of the place; in the circumpolar regions of the sky it may even become perpendicular to the horizon: in addition to which, the observer's head is frequently so twisted, especially in using an achromatic telescope, that all accustomed ideas of the position of objects are thrown into confusion. It will be necessary, therefore, for the student to attend carefully to the course of the principal star through the field, which gives the parallel of declination; to estimate the position of the smaller object by referring to the diagram; and to compare this estimation with the measured angle: the eye will thus require a training which will prove very serviceable. If he possesses the habit of observing with both eyes open (a very desirable one, as producing less uneasiness and fatigue), a glance with the unarmed eye at the polar star, if within convenient distance, will help to fix the line of the meridian; from the inversion in the eye-piece, the pole will of course stand at 180° in the diagram.

4. *Colour.*—This, when fully developed, and especially when strongly contrasted, adds a charm to many a pair otherwise less interesting from the relative fixity of its components. There is, however, a good deal of uncertainty about it, as there is some diversity in the pictures in different instruments, and much discrepancy in the estimates by different observers. The achromatic, from its inherent defects, the uncorrected or "outstanding" colours, which cannot be united with the rest, necessarily gives an image whose tint is *minus* that outstanding colour; thus, as the latter is usually blue or purple, a white star will be found to have a yellowish or slightly orange cast. Reflectors are in theory exempt from this imperfection, but unless the speculum is of perfectly white metal, and free from tarnish, they are apt to give a smoky hue. From this cause, or from some peculiarity of vision, Sir W. Herschel was so partial to ruddy tints, that his observations, in this sole respect,

do not afford so good a starting-point as might be desired; and it is well known that certain eyes, perfect in other respects, fail, more or less, and some even altogether, in their appreciation of colour. These circumstances throw an unfortunate impediment in the way of a curious inquiry, and one well adapted for general prosecution—whether stars are liable to any change of colour. The wonderful New Star of 1572 passed through various tints in its diminution, and there is sufficient evidence to prove that Sirius, now of so brilliant a white, was once decidedly red, Seneca says even redder than Mars; and other similar suspicions have been entertained. Upon what such alterations may depend, or what corresponding changes they may indicate in the constitution of those far distant suns, is of course wholly unknown, but they form a point of great interest. It is here that a multiplication of observers may be of much service, as the combination of the impressions of many eyes is the most probable way of eliminating individual peculiarity, and testing suspected changes; and it is here that amateurs, with eyes sensitive to colour, and provided only with telescopes of adequate size, may afford assistance as effectual as could be derived from all the appliances of a regular observatory.

When a large star is of any decided hue, it may be naturally expected that its feebler companions may from contrast assume the complementary colour; just as the moon, viewed near, or just after, a powerful yellow artificial light, will appear decidedly blue, or as Schmidt saw it, of a lively green, among the ruddy clouds of volcanic smoke and steam, which encompassed his observatory upon Vesuvius during the great eruption of 1855. In such cases the accidental colour of the smaller star will disappear when its overpowering neighbour is hidden behind the edge of the field, or a thick wire introduced into it. But in many instances the colours, though complementary, as red and green, or yellow and purple, or orange and blue, are proved, by the same means, to be independent; and it is a curious and suggestive sight, to behold the whole light of the spectrum thus divided in unequal proportions between two companion suns. As a general rule, Struve found that when a pair of stars are not both of the same colour, the larger verges towards the red end of the spectrum, the smaller towards the blue. He gives the following result of his observations:—375 pairs of the same colour and intensity; 101 of the same colour, but different intensity; 120 of different colours; 295 both white; 118 both yellowish or reddish; 63 both bluish. In cases of great inequality of magnitude, when the smaller star is blue, he found the larger, white in 53 pairs, light yellow in 52, yellow or red in 52, green in 16. He assigns no colour to very minute stars, but such were frequently seen by Smyth of a

beautiful blue tint. Instances of a ruby colour are to be found in the heavens, but only in solitary and not large stars.

5. *Variation* of light.—The experience of later times has shown the wide extent of this marvellous phenomenon, and every year is adding to the probability of the worthy old Hanoverian astronomer Schröter's idea, that variable light is present throughout the whole creation. It will be readily seen how favourable an opportunity is offered for its detection in nearly equal pairs, where juxtaposition gives an admirable test of change. But a more surprising and still more unintelligible development of this peculiarity comes out of the Dorpat observations. Struve has discovered what he thinks satisfactory evidence of alternate variation, each component taking precedence in turn, in 23 pairs, and has suspected it in 42 more. It may be remarked that it must be difficult to ascertain, in many cases, whether this variation is extended to both individuals, or is confined to one, as the relative effect would be the same upon either supposition; and it remains to be seen whether these alleged changes are equally apparent to other ages; all of them, at any rate, have not been so, but the subject is too interesting to be passed by lightly, and, as in the case of colours, it is from an average of not only many observations, but many observers, that these very delicate and almost evanescent data can be determined. The amateur who is not provided with a telescope equal to those of Struve and Smyth, need not despair, as, from some cause not yet clearly explained, but connected probably with the sensitiveness of the retina, inequality of light is found to be more perceptible when its absolute quantity is diminished in the use of a smaller aperture.

To this enumeration of the principal points to be noticed, we must add that the observer should record the *epoch of his observation*. This may prove not merely interesting to himself, but of more general value. Even a negative statement—as of apparent permanency—is of use if followed by positive change. Our readers may not have the means of executing those delicate measurements which decide the periods of revolution, but they may feel much interest in watching, year by year, the diminution or increase of distance, or progressive change of angle, which attests the fact; and memory, in such cases, is seldom to be fully depended upon. Astronomical dates are frequently given in decimals of a year, rather than in months and days; thus 1862·49 signifies June 30 of the present year. This mode of reckoning may be found in the *Nautical Almanac;* it has the advantage of conciseness, and ranges much better in column.

It may be well to remind the commencing student that as few, comparatively, of the planes of the orbits of these binary stars lie at right angles to our line of vision, they are for the

most part foreshortened in perspective; and hence circular orbits (if there be any) will usually be projected on the sky as ellipses, and ellipses will be thinned off till in some cases they are seen edgeways as straight lines, and the stars will appear, twice in every revolution, to close up into one, at least, with such optical means as are at our command. A true occultation is, however, probably extremely infrequent, as we have reason to think that the real discs of the stars are too minute to be perceived—the merest points conceivable. They have never yet been seen by mortal eye. The circular appearance which, in a fine state of atmosphere, a star exhibits in a telescope, is not its real image, but what Sir W. Herschel termed a "spurious disc," arising partly from peculiarities in the original constitution of light, and partly from unavoidable imperfection in the instrument. With low magnifying powers, indeed, this little disc is not to be distinguished from a point, but these are in general inadequate to the purposes of sidereal astronomy; as we employ higher magnifiers, we shall find that the point will expand into a little luminous circle, surrounded by one or two faint rings, which are present in every good telescope; one great test of goodness being the perfect circularity of the disc and rings; by increasing our aperture, we shall diminish the proportional diameter of the disc, and hence it is that the same magnifying power in a small telescope will fail in separating the discs of close double stars, which are readily divided by a larger one; but we have never yet succeeded, and have little hope that we ever shall, in contracting the disc to so minute a point as to be a true representation of the star. The progressive diminution of the discs, as telescopes attain greater magnitude and perfection, is at present but a remote approximation to the real image, as is conclusively shown by the instantaneous disappearance in occultation of a star even of the first magnitude, behind the slowly advancing limb of the moon; and hence it is highly improbable that a real eclipse of one star by another has ever been observed. In such a case, as Sir J. Herschel has remarked, the fact would become evident to the naked eye, from the diminution of the total amount of light emitted jointly by the pair.

The possessors of small telescopes will be glad to find that a considerable number of interesting double stars, and even binary systems will be within their reach. They will, of course, not expect to distinguish the closer pairs, or to pick up the minuter *comites;* nor will they succeed very well in the discrimination of colour, which becomes more distinct and full in proportion to the quantity of light. But they may gain such a glimpse into the interior of the temple as may give them some slight idea of its grandeur and glory, and in these days, when

excellence and costliness are no longer inseparably associated in the optician's workshop, they may be induced, by what they see imperfectly, to arm themselves with the means of seeing to more advantage. We shall in future papers indicate to amateurs a wide and interesting field in which their labours will find abundant scope.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

GEOLOGICAL SOCIETY.—*January* 22.

Discovery of Bone and Flint Arrow-Heads, etc., in Hyæna Cave, at Wookey Hole, Somerset.—In a ravine at the village of Wookey-Hole, near Wells, the River Axe flows through a canal cut in the rock. In cutting this passage, a cave, filled with ossiferous loam, was exposed, and its entrance cut away. In 1859, Mr. W. Boyd Dawkins and Mr. Williamson began to explore it by digging away the red earth with which the cave was filled, and continued their operations in 1860 and 1861. They penetrated 34 feet into the cave, which is hollowed out of the Dolomitic Conglomerate, from which have been derived the angular and water-worn stones scattered in the ossiferous cave-earth. Its greatest height is 9 feet, and the width 36 feet. Remains of *Hyæna spelæa* (abundant), *Canis Vulpes*, *C. Lupus*, *Ursus spelæus*, *Equus* (abundant), *Rhinoceros tichorhinus*. *Rh. leptorhinus* (?), *Bos primigenius*, *Megaceros Hibernicus*, *C. Bucklandii*, *C. Guettardi*, *C. Tarandus* (?), *C. Dama* (?), and *Elephas primigenius* were met with; remains of *Felis spelæa* were found when the cave was first discovered. The following evidences of man were found in the red earth of the cave—chipped flints, flint-splinters, a spear-head of flint, chipped and shaped pieces of chert, and two bone arrow-heads. Mr. Dawkins believes that the conditions of the cave and its infilling prove that man was contemporaneous here with the extinct animals whose remains were found, and that the cave was filled with its present contents slowly by the ordinary operations of nature, not by any violent cataclysm.

Natural Formation of supposed Flint Arrow-Heads.—Immediately beneath the surface-soil at Croyde Bay, North Devon, at the mouth of a small transverse valley, Mr. Whitley found broken flints in considerable number. About ten per cent. of the splintered flints at this place have more or less of an arrow-head form, but they pass by insensible gradations from what appear to be perfect arrow-heads of human manufacture to such rough splinters as are evidently the result of natural causes. Hence great caution should be used in judging what flints have been naturally, and what have been artificially shaped.

[We regret that we cannot, in the present number, lay before our readers such a summary of the remarkable address read by Professor Huxley (in the absence of the President) to the Geological Society, on the 21st ult. It was in every respect a striking paper, calculated to exert a powerful influence upon the thoughts of scientific men. We can only now advert to its masterly analysis of the negative evidence by which palæontologists and others have built up many of the assumptions on which too much of recent geology has been based. Mr. Huxley shows that we have no reason to assume that similar formations in different parts of the world were deposited at the same time, or even in the same age or era. What we know is the order of superposition in stratification, and something of the order of succession in the plants and animals which fossil remains present to our view; but we do not know, and have no right to infer, that chalk formations or Silurian formations in different countries, bear to each other any relation of contemporaneity; nor have we any justification for assuming that we can discern the beginnings of life in the oldest rocks in which organic remains have been discovered.

From this branch of his subject the learned Professor passed to a consideration of the arguments that support prevalent theories of development, either regarded as a progress from a general to a specialized structure, or as an advance from embryonic to adult forms during the long course of ages. Here, as in the former case, he demonstrated the insufficiency of the data on which broad assertions are very often made; and showed that the extent of changes in the organic world during past geological eras was much less than is commonly asserted, and not brought about in such an abrupt and violent way.—Ed.]

ROYAL SOCIETY.—*January* 23.

Influence of Physical Agents on the Development of the Tadpole.—It is usually believed, in consequence of a statement by Dr. Edwards, of Paris, in his work, *On the Influence of Physical Agents on Life*, that the presence of light is necessary to the development of the tadpole into the frog. In a paper read before the Royal Society, Mr. Higginbottom has demonstrated the fallacy of that opinion. His experiments were performed in cellars in Nottingham cut out of solid rock, not subject to any great change of temperature, and into which no solar light ever enters. The lowest cellar is 30 feet deep, and has a mean temperature of 51° Fahrenheit. Ova just deposited were placed in the cellar on the 11th of March, and on the 31st of October the first was fully developed in the form of a frog; whilst ova placed in the dark in a room at the temperature of 60° Fahrenheit were fully developed on May 22nd, twenty-three weeks earlier than those in the cellar; proving that the development of the ova depended on temperature, and not on light. In fact, an excess of light retarded the development.

Mr. Higginbottom attributes the failure of Dr. Edwards's expe-

riments to the fact of the ova being placed deep in the water, as they will not develope even when submerged a few inches.

Dr. Edwards also stated that light was essential to the metamorphosis from the tadpole to the frog, stating that tadpoles deeply submerged in a perforated box in the river Seine do not become transformed. Mr. Higginbottom maintains that the arrest of development is to be attributed to the seclusion from the atmospheric air, and not from light, as the tadpoles, both of the frog and triton, obtain their perfect development in the dark rock-cellars of Nottingham, the rapidity of the change varying with the temperature. He states, that "The situation in which Dr. Edwards placed the tadpoles, 'some feet below the surface of the river' in his experiment, would inevitably prove unsuccessful in the full development of the frog. I have always found the transformation, both of the triton and of the frog, equal, in the same temperature, both in the light and in the absence of light, if placed in shallow water; but during their metamorphosis they must be allowed to rise to the surface of the water to obtain air, or they become asphyxiated. To prevent this, I placed stones in the vessel, and allowed them to leave the water for the purpose of atmospheric respiration. The metamorphosis of the tadpole, when at its *full* growth, requires about fourteen days to bring it to the condition of a frog. About the termination of that period, the diminution of the body is so great, and also the absorption of the expanded caudal extremity is such as to diminish cutaneous respiration. Respiration by the lungs becomes absolutely necessary to prevent the animal from becoming asphyxiated, which would be the case if it remained in the water; requiring then not an aquatic, but an atmospheric medium of respiration. It may be observed that after the tail is partially absorbed, leaving only a portion of the solid part, the asphyxiated state has commenced; the little animal, with open mouth, gasps for breath; but if removed into atmospheric air, the mouth is directly closed, and respiration is effected through the nostrils with perfect freedom; the animal is restored directly, jumps about and is lively."

ROYAL GEOGRAPHICAL SOCIETY.—*January* 27.

Ascent of Kilimandjaro.—Mr. Thornton's paper on the Ascent of Kilimandjaro was read. The journey of the Baron von Decken and Mr. Thornton, from the coast to Kilimandjaro and back again, occupied 101 days. The mountain was ascended to the height of 8000 feet; and was seen to be incontestably snow-capped. The scientific confirmation of the statements of Mr. Rebmann is satisfactory, in the first place as settling what has long been a doubtful point, viz. the existence of snow-covered mountains in Africa at so short a distance from the equator; and, in the second place, as proving the truthfulness of the Missionary reports. Mr. Thornton states that, considering the imperfection of the instruments for making calculations which they possessed, the observations and maps of the Missionaries are wonderfully accurate. The Kilimand-

jaro mountain was observed from various points. It is said to rise very gradually from the surrounding country. The summit, from one point of view, presents the appearance of a great dome, and from another that of a cone with a small plain on the top. Two other high peaks, belonging to the same group of mountains as Kilimandjaro, have been observed. One of these, at a distance of about 15 miles N., appears to have a height of 17,000 feet, and the other, apparently 60 miles W., seems to be 18,000 feet in height. The explored peak is decidedly volcanic; and Mr. Thornton considers that it may be merely the remaining peak of a vast volcano, by far the larger part of which has subsided to a lower level. The central axis of the mountains appears to run from N.E. to S.W.; and it is thought probable that, when this is reached, granite will be found.

Sir Henry Rawlinson read a letter from Colonel Pelley, H.B.M. Consul at Zanzibar, stating that Baron von Decken intended to continue his explorations, and that the river Ozee, which flows into the Indian Ocean, not far south of the Equator, and is supposed to rise in the northern prolongation of the Kilimandjaro range, was beginning to attract attention.

Ascent of the Ogun (the Abbeokuta River), by Capts. Burton and Bedingfield and Dr. Eales.—Captain Burton recorded his ascent of this river, and his opinion that the whole country, from the Niger to the Volta, is well suited for the growth of cotton. He thinks that the population of the district has been under estimated, and that, instead of being called 100,000, it ought to be 150,000. He rather scoffs at the King of Dahomey's Amazons, and thinks that their number is less than previous travellers have stated.

Captain Strickland made some remarks with regard to the Abbeokutans. He said that they displayed great aptitude for trading, and might be called the Jews of Africa. Abbeokutans taken as slaves to Brazil, soon purchase their freedom, and also that of others who are brought to that country as part of cargoes of slaves. They are intelligent, and appear to preserve the remains of an ancient civilization.

THE ROYAL SOCIETY.—*January* 30.

Absorption and Radiation of Heat by Gaseous Matters.—Dr. Tyndall described the results of his continued investigations on the absorption of heat by gases and vapours. The absorption of radiant heat by atmospheric air in a short tube, and at a tension of thirty inches, being taken as 1; Chlorine would be 36; Hydrochloric acid, 62; Carbonic acid, 90; Sulphuretted hydrogen, 390; Olefiant gas, 970; Ammonia, 1195. The absorption of radiant heat by vapours was also found to be very considerable, and even small quantities of perfumes, when diffused through common air, increase its power of arresting heat to an extraordinary degree; thus the absoptive power of air charged with the perfume of patchouli is 30 times greater than that of pure air; lavender increases the power

to 60 times; and aniseed 372 times the natural amount: hence the perfume arising from a bed of flowers increases the temperature of the air around them by rendering it more absorptive of radiant solar heat. The vapour of water, when present, increases the absorption of heat by the air in a very extraordinary degree; during the month of October last Dr. Tyndall found that the atmosphere was 60 times more absorptive than dry air, owing to the continued moisture. Dr. Tyndall infers that as the amount of vapour diminishes rapidly at a distance from the earth's surface, the sun's rays are not sensibly arrested until they reach our atmosphere, but that, on the other hand, the heat of the earth is prevented from being radiated into the free space and lost, by the existence of vapour in the air; and owing to the influence of this action, he thinks that even those planets most distant from the sun may have a temperature sufficiently high to render them inhabitable.

CHEMICAL SOCIETY.—*February* 6.

Formation of Siliceous Minerals.—Several interesting communications were made to this Society. Professor Bloxam, of King's College, read a paper on the presence of arsenic in sulphuric acid, and the great difficulty of obtaining chemical substances absolutely free from that element. Mr. Dugald Campbell, in the discussion which followed, made an interesting statement relating to the almost invariable presence of arsenic in hydrochloric acid, and traced its origin to the sea-salt used in the manufacture of that acid: arsenic, as is well known, being, in common with silver, copper, etc., an invariable constituent of the waters of the ocean. In all the above cases the arsenic exists in a proportion far too minute to be discoverable except by the most delicate tests. Mr. A. H. Church then gave the results of some experiments on the aqueous solution of silica, which chemists are now able to prepare of considerable strength by means of the dialytic process of Professor Graham. He found that a solution containing three per cent. of dry silica, or flint, was as transparent and nearly as mobile as water, when freshly made, but that it soon became of the consistency of glycerine, and finally, after six days, gelatinized completely. A very large quantity of the pure aqueous solution of silica may be changed from the liquid into the solid state in the course of ten minutes by the fifteen-thousandth part of a grain, or less, of carbonate of lime; the process of the transformation into a firm jelly of several ounces of the limpid solution by means of a few minute particles of the carbonate of an alkaline earth being very remarkable. Mr. Church pointed out the important geological effects which might have had their origin in an aqueous solution of silica, referring more especially to the formation of an interesting mineralized fossil known as "Beekite." This substance, originally coral or shell, has been transformed into chalcedony or flint, having lost nearly all its carbonate of lime. Mr. Church had succeeded in effecting a similar transformation in recent coral by means of the infiltration of an aqueous solution of silica.

He pointed out the almost constant presence of silica in the waters of the earth, as enhancing the probability of his views. The tendency to circular or globular arrangements often observed in siliceous minerals was compared by the author to certain minute rings observed to form during the evaporation of an aqueous solution of silica. A second paper relating to silica was also read at the same meeting. In it several springs in New Zealand, very rich in silica and alkaline silicates, were reported on, and the beautiful quartz-sinter described, with which they rapidly incrust surrounding objects, such as leaves, flowers, buds, and fruits. A singular crystallization of large quantities of phosphate of lime occurring in cavities in teakwood was also brought under the notice of the Society by Professor Abel.

ROYAL INSTITUTION.—*February* 7.

On the Fossil Remains of Man, by Professor Huxley.—The brain-case of man has many varieties of shape and proportion among the different races of men.

The *skull of a Negro* was shown; its breadth was small in proportion to its length—in fact, was only six-tenths of it. The *skull of a Turk*, on the contrary, was, in breadth, nine-tenths of its length. All skulls come under one or other of these classes. Taking eight-tenths of the length as a standard from which to classify skulls according to the proportion between their length and breadth, all that have for breadth a less proportion than eight-tenths of the length are termed *dolichocephalic*, or long-headed; all that have a greater proportion, or even that proportion (eight-tenths), of the length in the breadth, are termed *brachycephalic*, or round-headed.

Skulls which are of the second class generally have the jaws *orthognathous*—nearly or quite in a perpendicular line with the forehead. Those of the first class have the jaws *prognathous*, or more prominent than the forehead.

If a line be drawn on a map from the centre of Russian Tartary to the Bight of Benin, it will be found that north and east of this line the heads are of the brachycephalic type; south and west of it they are dolichocephalic; north and east the faces are orthognathous; south and west, prognathous. This, however, is a very broad statement of fact. Near these points may be found heads of all varieties of breadth; but, as a rule, the round headed races, Mongols, Tartars, Turks (modified Tartars), are north of this line, and long-headed, Negro races are south and west of it.

These great changes are doubtless influenced by, and may be, in great measure, caused by difference of physical condition. So great are the differences, that these points may be called the ethnological poles. At the northern end are cold, barren, treeless plains; at the southern, the warm, rank fertility of the tropics. As we go away from these ethnological poles, we find, in going from Tartary, the Chinese become longer-headed and more prognathous; the Greenlanders are long-headed, so are the Esquimaux, so are the

North American Indians. In fact, all heads vary as we depart from the ethnological poles.

A line drawn from the British Isles, through Europe and Western Asia to Hindostan, represents the Ethnological Equator, along which the skulls are found to be *oval.*

The question arises whether the same varieties of the human race have always inhabited the regions of the earth in which they are now found. In Asia, in Africa, all remains that are found are of races similar to those now dwelling in the countries. In North America, in the valley of the Mississippi, are found, however, the remains of a race entirely different from those who now live there—a race whose remains are the great earthworks found in that region.

When we come to Europe, however, we find, first of all, everywhere the remains of the great Roman people. In northern Europe we find the remains of a long-headed people, acquainted with the use of iron; the ancestors of the present Germanic races. These, however, were preceded by a race smaller of stature, long-headed, like the Hindoos, unacquainted with the working of iron—workers in *bronze* —and traces of them are found all over Europe.

But *behind these*, and earlier than these, come the remains of an earlier race still—a ruder race—who possessed weapons of *stone* ground to an edge. These were a rounder-headed people—the transverse measurement of the skull was eight-tenths of the longitudinal—but the forehead was flat, the supra-orbital ridges were extremely prominent, and the jaws were prominent, though *not* decidedly prognathous.

At what distance from our epoch was this Stone Period? It is impossible to state in years. In Denmark, there are vast peat-bogs. In the upper layer of these are found *beech* trees, the trees which which now form the forests of Denmark; and in these bogs are found the remains of the *iron age.* Deeper than these is a layer of peat, in which are imbedded *oaks* of enormous size—oaks, whose circumference speaks of centuries of growth. With the oak trees are found the implements of bronze.

Deeper yet, is another stratum, in which are found pines, which show by their long stems that they have grown up in dense forests, into which the light could hardly penetrate; and at the very bottom of these pine bogs are found the stone weapons; under them, again, is found peat, in which are found no weapons of any kind, or any remains of man.

It is not possible to make any calculation of the years that have elapsed between the stone period and the present day—the consideration of the immense length of time which must have been occupied in the formation of these bogs can alone furnish us with any idea on the subject. But before even these bogs were formed, there was a time when the physical features of the country were totally different from what they now are, when the urus and bos primigenius, the fossil elephant, hyæna, and cave bear roared over the land. The question has arisen, was man contemporaneous with these animals? The recent numerous discoveries of stone weapons, chipped to an edge, and fossil bones acted upon by instruments, tends to the con-

clusion that man was co-existent with these animals. The question then arises, what races of men? This has been answered by the discovery of a well-developed dolichocephalic human skull, in a cave at Engis, in Belgium, associated with the remains of the animals enumerated above. Since that, a skull has been discovered at Neanderthal, near Düsseldorf, very different, and much lower in type than that of the Engis cave. It is a flat-topped skull, so much so that there was a question whether or not its shape had been produced by artificial means, and the supra-orbital ridges are extremely projecting.

An interesting question arises as to the relations which existed between the possessors of these skulls. Could they be all of one race, or were they of entirely different races? This question was settled by an examination of skulls which belonged to Australian aborigines—the purest existing race of human beings. In a large collection of these, there were found skulls which almost exactly matched both the Engis and the Neanderthal skulls, in actual dimensions; and which certainly differed as much from each other in relative proportion as did these. A remarkable fact is, that the present aboriginal Australians resemble these ancient people in modes of life as well as in development of skull. Like them, they use stone weapons; like them, they use the bones of the kangaroo, as they did the bones of the deer and *urus;* like them, they make mounds of refuse skulls; and like them, they build their huts on piles in the water.

The Engis skull can, however, be paralleled in proportions even by English skulls.

Far back as is the age of the men who made and used the flint implements, still farther removed is that at which must be placed the commencement of the human race.

ROYAL HORTICULTURAL SOCIETY.

The Artesian Well at South Kensington.—Mr. Nesfield's bold and original design for these gardens was characterized by the extensive series of water scenes, canals, cascades, fountains and ponds, as much as by its grand architectural accessories. The plan was adopted without any consideration being given to the question how the immense body of water that would be required for the fountains was to be supplied. The council knew that by payment of a certain rent the resources of a water company would be available, and to fill the canals, and work the fountains, was a matter of no immediate concern. When this question came to be considered seriously, it appeared that there was every probability of a sufficient supply being obtainable by the sinking of an artesian well in the garden, the first outlay for which would be as nothing compared with the large yearly rent for a supply from a water-company. Messrs. Easton, Amos, and Sons, were so confident that the chalk would yield water in abundance, that they undertook the work of boring on the condition that if unsuccessful they should receive no pay. The work has been

completed, and in spite of all the risk attending such operations, has proved successful beyond all previous undertakings of the kind within the London basin. The engineers guaranteed a supply of seventy-five gallons per minute, but the well is capable of supplying ten times that amount; it can, in fact, supply a million of gallons in twenty-four hours, and will apparently be wholly unaffected by local circumstances, and but slightly by the changes of the seasons. The total depth sunk and bored is 401 feet, a well having been sunk to the depth of 226 feet, and a bore thereafter carried down 175 feet farther. In boring this well, it was found the London clay forms a much thicker stratum at Kensington than usual. Below it the strata are successively mottled clay, pebbles, greensand, grey-sand, flints, and lastly the chalk. But there is a circumstance of peculiar interest in connection with the enormous capabilities of this well. Whilst boring through the chalk, the instrument came upon a fissure, and dropped down a space of several feet, indicating that the boring had penetrated into one of those subterraneous streams which are known to occur in the chalk, and which when met with appear to be incapable of exhaustion. This, and the well at Trafalgar Square, are the only two in which this fortunate correspondence of the bore into a fissure has occurred, of the many wells bored by Messrs. Easton and Amos; all other in the metropolis being dependent on the supplies which percolate through the chalk into the well. This running stream, or natural main, may be the same as that hit upon in boring the well at Trafalgar Square, but at present there are no evidences of identity. Fortunately too the water from this well is fit for garden purposes, and the cost of the undertaking will prove to be one of the best investments of the funds of the Society, both for the maintenance of the garden and the interests of the fellows. It is unquestionably the finest well in the metropolis, a triumph of engineering, and an important contribution to our knowledge of the characteristics of the London basin.

NOTES AND MEMORANDA.

Physiological Effects of Milk.—Mothers have long been aware of the fact that their infants were affected by any changes in the composition of breast-milk, brought about by particular kinds of food, medicine, or other disturbing causes; and a French doctor, M. Labourdette, takes advantage of this circumstance by administering to the mother the physic he wishes to operate upon the child. M. Flourens also has made divers experiments with pigs and other animals. He coloured the maternal food with madder, and in twenty days found the bones of the little sucklings tinged with that dye. At the meeting of the British Association in 1860, Mr. Gibb, referring to Vogel's discovery of vibrions in human milk, stated that a child had been brought to him in a state of emaciation. The mother appeared in good health, and her milk was rich in cream and sugar, but it contained numerous vibrions. Subsequent observations confirmed the opinion that milk containing infusoria reduced the children who were suckled upon it to skin and bone.

Fertility of Hybrids.—M. J. G. St. Hilaire, after collecting facts from various sources, and making numerous original experiments on the reproductive powers of hybrids formed by the alliance of species of the same genus, arrived at

the conclusion that there were a great many sterile hybrids, and also a great number that were imperfectly fecund; but that there were others which possessed the faculty of reproduction either with stock species or among themselves. It would be of the highest importance to ascertain under what circumstances the fertility takes place, and to what extent hybrids are formed by animals in a wild state. M. St. Hilaire considered such commingling of species occurred much oftener than is usually supposed.

Antiquity of Bones.—M. J. P. Couerbe has proposed to the French Academy of Sciences a clever, but uncertain mode of ascertaining the date of human bones discovered in tumuli or similar situations. He analyzed portions of skeletons dug up at the Château of Vertheuil. The bones were friable, but well preserved; and from part of an arm-bone he obtained carbonate of lime, 15·50; phosphate of lime, 67·17; phosphate of magnesia, 3·16; oxides of iron, manganese, and aluminium, 1·50; silica, 2; organic nitrogenous matter, 10·47 per cent., and traces of chlorides. Berzelius obtained 33 per cent. of nitrogenous organic matter from fresh bones, and M. Couerbe considers that it is possible to discover the rate at which this matter disappears from buried remains, and consequently that the age of any fragments could be ascertained by the results of analysis. He tells us that Vogelsang could only obtain traces of organic nitrogenous bodies in bones which had been eleven centuries under ground; and hence he concludes, with perhaps more haste than judgment, that these elements disappear at the rate of three per cent. per century. He admits that difference of soil and other conditions would materially affect the question to be solved, but nevertheless considers that if the loss of organic matter experienced by any bone be divided by three, an approximate age will be obtained in centuries.

Embryogeny.—M. Ch. Robin observes: "Under the name of 'mucous globule,' 'hyaline corpuscle,' etc., most embryogenists have distinguished a translucent globule which appears on the sides of the embryon. Once produced, it remains, under the vitelline membrane, a stranger to the phenomena which take place around it, and it is abandoned, with the aforesaid membrane, when the hatching (*éclosion*) takes place. Becoming useless as soon as formed, its production has prepared the way for the segmentation of the vitellus." He proposes to call these agents in generation "polar globules," because their appearance "marks some hours in advance the pole of the vitellus which is about to be depressed." After various details, he remarks: "It is by germination, and with the aid and at the expense of the substance of the vitellus, that the polar globules are produced. Among all the vertebrate and most of the invertebrate animals, their appearance is followed by the segmentation of the vitellus. But there are animals, such as gnats (*Tipulaires culiciformes*), among which the vitellus does not undergo segmentation, and the cellules of their blastoderm originate by germination, as the polar globules do in other creatures."—*Comptes Rendus.*

Growth of Coral.—M. de Lacaze du Thiers, having been directed by the Governor-General of Algeria to report on the reproduction of coral, devoted himself to the requisite observations, and communicated the results to the French Academy. He found coral branches to contain male polyps, females, and hermaphrodites, the latter being the least numerous. One or other sex usually predominated in a particular branch, and when fecundation was not the result of hermaphroditism, the currents of the water carried the male seed just as the air carries the pollen of diœcious plants. In lively specimens, the male polyps may be seen to emit a white fluid, which produces a milkiness in the water, and diffuses the spermatic elements. He found some difficulty in distinguishing the seminal from the ovigerous capsules under a hand magnifier, but the microscope revealed egg appearances in the latter, and spermatozoa in the former. The incubation takes place in the digestive cavity, the coral is viviparous, and its young resemble little worms, which move with agility. They swim backwards, and after becoming fixed, experience curious transformations in reaching the form of the perfect animal.—*Ibid.*

Adulteration of Tin-foil.—As many experimenters might be under the delusion that tin-foil was really composed of tin, it may be as well to cite the

analyses of Mr. Baldock, who found various specimens to contain lead, the purest having rather more than 34 per cent. of that metal, and the worst 86 per cent.

CARBOLIC ACID.—Dr. Crace Calvert calls this substance the most powerful preventive of putrefaction with which he is acquainted. By its aid he succeeds in preserving gelatine solutions, and preparations of starch, flour, etc. It prevents the conversion of tannin into carbonic acid and sugar, and arrests lactic fermentation. Diluted with from two to seven parts of water, it is found useful in putrid ulcers and sloughing wounds. The non-chemical reader may be reminded that carbolic acid is very similar to creosote, and obtained from coal-tar.

DIVISIBILITY OF MATTER.—A writer in the *Chemical News* proposes, as an illustration of the mechanical subdivision of matter, that a film of gold leaf reduced by Faraday's plan, through the action of cyanide of potassium, so as to be quite transparent, and about 1-3,000,000th of an inch in thickness, should be divided by cross-lines 1-80,000th of an inch apart, like those in Norbert's test-plates, belonging to the highest series which the microscope will revolve. By this means squares of gold might be obtained so small, that three billion eight hundred and forty million of them would occupy no more than a single square inch; and yet each one would be distinctly visible under the best objectives of modern microscopes.

THE COMET OF 1861.—The *Comptes Rendus* of the 13th of January contains an elaborate paper by M. Faye on "the Figure of the Great Comet of 1861," in which he first comments upon what he terms the "cyathiform," or "nucleated cup-shaped anterior emission." He alleges various reasons for considering this emission to have the shape of a cup, with reversed edges. He remarks that in attempting to compare theoretical figures with the forms naturally observed, it is necessary to remember that the former repre-ent geometrical surfaces without thickness, while the latter exhibit considerable thickness, and are not homogeneous in substance. He further compares the cometary emission forms to the conical or spherical sheets of water in wide-spread fountain jets, which after a certain limit lose their regular shape, and are resolved into torn and divided streams (*lambeaux*) and drops. M. Faye states that these details may be conveniently studied by causing the flame of a spirit-lamp to be deflected by an obstacle held in a horizontal plane. He also describes "a posterior conoidal emission," which he finds prolonged far into the tail, following its curvature, and gradually enlarging itself until it presents the perspective appearance of two distinct branches.

INTRA-MERCURIAL PLANETS.—The same number of the *Comptes Rendus* contains an extract from the *Annales de l'Observatoire* on the theory of Mercury, detailing various objections to the hypothesis of a large planet comparable with Mercury in size, and circulating within its orbit, and suggesting the belief in a series of asteroids, whose joint action might produce the disturbance which has to be accounted for. The writer urges the importance of noticing every regular spot that may appear on the disk of the sun, in order to ascertain whether it possesses the character of an asteroid.

VELOCITY OF BOLIDES.—M. Petit estimates the velocity with which the bolide of the 9th of December, 1858, passed over the communes of Muret, Longage, etc., at 5200 mètres per second, and its height above the earth during the explosions at 5000 mètres. A previous meteor (13th September, 1858) had an elevation of 220 kilomètres, and a velocity of 29 kilomètres. The mètre is 39·37100 English inches, and the kilomètre 4 furlongs 213 yards 1 foot 10·2 inches. M. Petit observes that the last-named meteor exhibited a brilliant light, far beyond the limits usually assigned to our atmosphere.

PHOTOGRAPHY AND ETHNOLOGY.—The Russians have taken photographic portraits of the various inhabitants of the Steppes of the Oural, with a view to ethnological studies. One view gives a profile, and another a full face; and the subjects of the operation were shaved, so as to exhibit the true form and dimensions of the skull.

A NEW VOLCANO has appeared in the Planeito de los Vaqueros, Chili, in a

region of perpetual snow, and about twenty leagues from the Baths of Chillon, known for their hot sulphurous springs.

THE PETROLEUM SPRINGS OF NORTH AMERICA.—Dr. Abraham Gesner communicated to the Geological Society an account of these extraordinary springs, and an abstract of his paper will be found in the *Quarterly Journal*. The oil region comprises parts of Lower and Upper Canada, Ohio, Pennsylvania, Kentucky, Virginia, Tennessee, Arkansas, Texas, New Mexico, and California, reaching from the 65th to the 128th degree of longitude west, and there are likewise outlying tracts. The oil is believed to be derived from silurian, devonian, and carboniferous rocks, and is conjectured to be a product of the chemical action by which ligneous matter is transmuted into coal. Dr. Gesner also suggests that in some cases animal matter may have been the source of the hydro-carbon. To obtain the petroleum, borings are made through various strata to the depth of 150 to 500 feet. As a general rule, these borings pass through clay, with boulders, sandstones, and conglomerates, shale, bituminous shale, and then the oil, underlaid by the oil-bearing stratum of fire clay, containing fragments of stigmaria and other coal plants. As soon as the oil stratum is reached there is an escape of carburetted hydrogen gas, often violent enough to blow the boring-rods into the air. When the oil comes it is ejected with much force, sometimes rising to the height of 100 feet. Some wells have at first given 4000 gallons in six hours, and the average daily yield of mineral oils in the United States is estimated at about 50,000 gallons.

LAND ANIMALS IN THE COAL MEASURES OF NOVA SCOTIA.—Dr. Dawson has obtained numerous animal remains from the cliffs of the South Joggins, Nova Scotia, among them some reptilian skeletons, one of which, the *Dendrerpeton acadianum*, he considers the most perfect carboniferous reptile hitherto discovered. These were obtained from a tree trunk fossilized *in situ*, and it also contained, amongst other treasures, many remains of insects, the most interesting being a compound eye, with the facets perfectly preserved. Further details are given in the *Quarterly Journal of the Geological Society*.

NEW VOLCANIC ISLAND IN THE CASPIAN SEA.—In August last, the crew of the steamer "Turkey" discovered a new island in the middle of the Caspian, 23 fathoms long, 12 fathoms wide, and the height above the water about 6 feet. The soil is very loose, and smells strongly of petroleum. The new isle is in a line of volcanic action, from the mud eruptions of Kertch to the fires of Bakou. An account of its discovery appeared in the Russian *Naval Review*, a translation of which by Lieut. Lutke was communicated to the Geological Society, through Sir R. Murchison.

BAKEWELL'S COPYING TELEGRAPH.—We understand from Mr. Bakewell that he considers Bonelli's telegraph, noticed in our last Number, to be an imitation of his copying telegraph, to which a Council Medal was awarded at the Great Exhibition of 1851. The latter effects with a single wire what Signor Bonelli's telegraph does with twenty; and it was at once evident, when the method of copying writing by the means of electricity with one wire was shown, that a greater number would do the work more quickly, if cost were no object. We are informed that with eight or ten wires copies of writing may be transmitted with Mr. Bakewell's instrument at the rate of 3000 letters per minute.

HELIOCHROMY.—M. Niepcé de St. Victor has communicated to the French Academy an important step towards the fixation of heliochromic tints, which increases the hope that before long coloured objects may be successfully photographed. He states that he "obtains the heliochromic colours on a film of chloride of silver formed on a metallic plate." In preparing this plate he employs hypochlorite of potash, and he remarks, "this alkaline bath, although very variable in its composition, generally gives fine colours, only the bottom of the image remains somewhat dark, and divers causes occasion certain colours to dominate over the rest." Continuing his description, he observes, "it is known that to obtain the colours on a white ground it is necessary to heat the plate, before exposing it to the light, until the chloride of silver assumes a rosy tint, or to substitute for the action of heat that of light, in the manner indicated by M. C.

Becquerel. I conceived the idea of covering the chloride film, before exposing it to the light, with a layer of a saturated solution of chloride of lead mixed with enough dextrine to form a varnish." He found that the colours were produced with greater brilliancy on a plate thus prepared, and after their appearance the plate was heated over a spirit-lamp, not raising the temperature high enough to carbonize the varnish. "Under the influence of heat, the colours usually grow more intense, especially if the light has influenced the whole thickness of the chloride of silver; but if otherwise, the blues are turned into violets, and the blacks to reds." The result of the process is, "that the destructive action of light upon the plate is retarded, so that ten or twelve hours are necessary to destroy the colours, which, under ordinary circumstances, would disappear in a few minutes. Such is the state of heliochromy to-day, and if the problem of fixation is not yet solved, we may at least hope for a solution." M. Chevreul remarks that the discovery of the dextrine and chloride of lead varnish is a great advance, and he compares the sensitive films of M. St. Victor to the retina of the human eye.

A Living Skeleton.—Under this title a very remarkable monstrosity is exhibited at Lima, in Peru. The individual, whose name is Montaos, appears about thirty-five years of age, but he says he is only twenty-eight. He seems to enjoy good health, his complexion is rosy, his cheeks full, and his eyes bright. His arms are long and fleshless, his body flattened, the legs dried and bent up like those of a Peruvian mummy, and terminating into two small half-bent feet. He has never been able to stand, and presents himself for exhibition seated on a three-legged stool. Notwithstanding his unfortunate organization, he contrives to play the violin and accordion with considerable taste. His body has a slight power of motion backwards and forwards, and he is able to use one hand and arm. To play the violin, he fixes one end of the bow between his legs, and steadies the other with the upper part of his body. He then takes the instrument in his right hand, fingers the strings, and at the same time draws them across the bow. The accordion he manages by securing the loose portion between his body and left leg, his mouth seizes the upper part, and the fingers of the right hand touch the keys.—*From the "Camercio de Lima," January* 3, 1862.

Curious Effect of Vis inertiæ.—M. Tardiret states that if a perfectly smooth and polished plate of glass, ivory, or metal is caused to rotate with great velocity in a horizontal plane, it does not communicate its own motion to a highly-finished ball which may be placed upon it.

Action of Iodine on Tin.—In the *Comptes Rendus* (January 27th 1862) will be found a paper, by M. Personne, on the iodides of tin. To obtain a direct combination of the two substances, he placed 21 grammes of iodine and 10 grammes of powdered tin in a sealed tube. At about + 50° cent. (122° Fahr.) a violent action took place, accompanied by the evolution of light. After cooling, the tube was broken, and there was found in it a metallic button of tin, and a red substance highly fusible and volatile. This was the bi-iodide of tin SnI^2. This substance crystallizes in octahedra of a red-orange colour. It melts at + 146° cent. (294·8° Fahr.), and emits yellow vapours; at + 142° cent. (287·6° Fahr.) it solidifies. After vaporization, it condenses on cool bodies in beautiful needles, resembling in form those of sal ammoniac. It is decomposed by water, into hydriodic acid, and binoxide of tin. It dissolves in bisulphide of carbon, chloroform, and benzine, and likewise in anhydrous alcohol or ether; but, like bichloride of tin, it can enter into combination with these last solvents. It absorbs ammonia, and forms three compounds. The protoiodide of tin is obtained by dissolving powdered tin in concentrated hydriodic acid, or by a double decomposition produced by pouring a solution of protochloride of tin into a moderately strong solution of iodide of potassium. In concluding his paper, M. Personne observes that it results from the experiments which he details that the action of iodine on tin is precisely similar to that of chlorine or bromine on that metal, and the iodides of tin are analogous in composition and chemical properties to its chlorides and bromides.